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BEACHES AND DUNES of the OREGON COAST

U.S.D.A. SOIL CONSERVATION SERVICE

OREGON COASTAL CONSERVATION AND DEVELOPMENT COMMISSION

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BEACHES AND DUNES OF THE OREGON COAST

SUMMARY

The chairman of the Oregon Coastal Conservation and Development Commission requested the Soil Conservation Service, in cooperation with local Soil and Water Conservation Districts, to develop an inventory of all sand dune areas, both active and recently stabilized within the Oregon coastal zone. This study was developed pursuant to this request so that resource data about beaches and dunes could be put in a form that responsible individuals could use to make wise land use policy and implementation decisions.

The objectives of the inventory and accompanying report are (1) to present inventory resource maps of beaches, sand dunes, and interdune areas, by coastal counties, (2) to explain the components of the beaches and sand dune resources that reflect the carrying capacity and wise use of the resources, (3) to present illustrations and tabular data about the beaches and dunes mapping units, and (4) to provide interpretations of the sand dune inventory mapping units with regard to use characteristics.

The study updates and presents beaches and dunes data on small scale maps for regional evaluation. Extensive steroscopic investigations were made in the office and coordinated with field investigations.

The study results indicate that the beaches of the Oregon coast are the key resource in the development of sand spits formed from littoral drift and associated sand dunes. The three resources are dependent on sand, which is becoming increasingly in short supply.

The coastal dunes of Oregon can be divided into four regions based on shoreline and dune formation characteristics. The first region is quite different from the others and evidences the dramatic influence of the Columbia River. The shoreline has advanced seaward in the region creating an almost continuous series of foredune ridges which parallel the beach. This region is called the Clatsop Plains and extends south from the Columbia River for 18 miles (see Map Appendix, Sheet 1, Clatsop County).

The Columbia River spit in the first region, has a northward trend and has been significantly modified since 1885, when construction of the south jetty began. This construction blocked wave

action across the Clatsop Spit and sand accumulated on the south side of the jetty where the beach grew rapidly seaward. The prograding beach, along with the destruction of the natural sand dune vegetation by overgrazing and fire resulted in the development of about 3,000 acres of exposed active sand dunes. In 1935, the Soil Conservation Service and others established a work area for the primary purpose of stabilizing these shifting sands. By 1941 most of the active sand areas in Clatsop County were stabilized.

The second region, extending 125 miles from Tillamook Head in Clatsop County to Heceta Head in Lane County, is characterized by a retreating coastal terrace shoreline with isolated active open dune sand areas and associated beaches, which are separated by headlands and a rock shoreline. (See Map Appendix, Sheet 2, Clatsop County, Tillamook County, Lincoln County, and Lane County.) These active dunes usually occur adjacent to bay and river mouths and are usually parabolic dunes associated with blowouts in varying stages of degradation. The open dune sand areas occurring in Tillamook and Lane Counties have a high recreation use.

About 35 percent of the open dune sand conditionally stable mapped on the Oregon coast occurs in this region, and 78 percent of the natural open dune sand in Lincoln County has been recently stabilized.

Tillamook County has the highest percentage of active foredunes on the Oregon coast, with 19 miles of this mapping unit present. Many of these active foredunes have been built upon to obtain an ocean view, with resulting sand accumulation in and around the buildings. There is only a limited occurrence of natural wet deflation plain in this region, and most of this important wildlife habitat have been drained. Therefore, in this region some of the open dune sand has been removed from recreational use, and much of the wet wildlife habitat has been changed to other uses.

The third region, called the Coos Bay dune sheet, is formed on a large coastal terrace which is 54 miles long. From Heceta Head in Lane County to Cape Arago in Coos County, the continuity of the dune sheet is broken only by the Siuslaw and Umpqua Rivers and small streams as they flow into the ocean. This has resulted in the development of massive, complex, and heterogeneous active dunes, some of which reach heights of 165 feet. Over 85 percent of the active dunes on the Oregon coast occur in this region. The open dune sand mapping unit is the most significant active dune with about 15,500 acres mapped. These dunes appeal to visitors and are inviting for both pedestrian and vehicle use. Most open dune sand in this region occurs in the Oregon Dunes National Recreation Area.

About two-thirds of the younger stabilized dunes in the Oregon coastal zone occur in this region. These dunes offer the greatest opportunity for man-made facilities, and contain abundant habitat for many species of birds, mammals, amphibians and reptiles. Most of the wet interdune and wet deflation plain areas also occur within this region. These areas are extensively used as wildlife habitat, particularly the broad flat wet deflation plain areas.

The fourth region lies between Cape Arago in Coos County and the California border. The only significant active dunes occur in a 12-mile coastal strip bisected by the Coquille River. South of Cape Blanco, the shoreline is steep and rocky; therefore, most dunes occur adjacent to mouths of creeks and rivers.

The younger stabilized dunes are not massive or of great height but they extend inland as much as a mile because of the level terrain. Older stabilized dunes associated with the coastal terrace extend up to about 3.5 miles inland. About two-thirds of the older stabilized dunes in the Oregon coastal zone occur within this region. These dunes offer about the same opportunity for man-made facilities as the younger stabilized dunes. This unit has a more permanent vegetative cover, and more well developed soils than exist for any other dune or interdune mapping unit. The older stabilized dunes also have a greater tendency to resist man's disturbance than any other mapping unit. However, deep excavations can expose underlying sand to the wind. A greater number of wildlife species occur in the older stabilized dune mapping unit than in any other mapping unit. The diversity is a result of the open canopy, well developed shrub layer, and abundance of snags and trees. Old growth timber occurs in this mapping unit and is critical habitat for the bald eagle, osprey, red-tailed hawk, and great horned owl.

A careful examination should be made of the beaches, sand spits, and sand dunes of the Oregon coast before future land use decisions are made. A set of land use policies is presented in this report that should help in critical land use decisions in sand areas. The policies are based on the fragile or stable nature of the resource.

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Herbert Schlicker, Geologist, Oregon Department of Geology and Mineral Industries, provided photographs and consultation.

Clatsop, Coos, Curry, Douglas, Lane, Lincoln, and Tillamook Soil and Water Conservation Districts.

Soil Conservation Service personnel who were the principal contributors to this study are: Frank Reckendorf, geologist; Clyde Bowlsby, soil scientist; William Billings, plant materials specialist; Robert Corthell, biologist, John Dennison, agronomist; Herbert Carnahan, engineer; James VanWoert, civil engineering technician; and Stuart Maxwell, civil engineering technician. Several SCS district conservationists also provided consultation, writing, and review assistance. They were Don Leach, Melvin Rigdon, Edward Olmsted, James Lockard, George Smith, James Wilson, Walter Risse, and Ralph Cleveland.

We appreciate the cooperation of the Portland District of the U. S. Army Corps of Engineers, and thank them for providing us with several illustrations that were used in describing the study areas.

INTRODUCTION

Although continental shelves and nearshore waters comprise only about five percent of the area of the world, about two-thirds of the world's population live near the ocean (16). Therefore, for long-term shoreland planning and management, we should understand our multi-faceted coastal resource.

Along the Oregon coast one can enjoy spectacular rocky stretches or fragile ribbons of sand called beaches. The beaches are fragile because they are composed of easily moveable sediment which is decreasing in supply. This sediment is generally composed of sand which is moved by longshore transport or wind action. Beaches are the key resource in the development of sand spits formed by littoral drift and sand dunes formed by wind action.

Sand dunes along the Oregon coast occur in areas such as sand spits or on coastal terraces near the mouths of rivers. In these areas blowing sand is entrapped by plants. Therefore, sand supply, and vegetation are the major elements in sand dune formation. In addition, wetness of the sand supply is an important factor in the development of the dune landscape.

This report will present inventory data and associated interpretations about beaches and sand dunes of the Oregon coastal zone. To avoid repetitive material, information about beaches and dune landforms and their common land uses, are presented in one section of the report. Specific characteristics of portions of the coast or of individual counties will be discussed in a descriptive section that refers to the maps.

HISTORICAL PERSPECTIVE AND STUDY REQUEST

The Oregon Coastal Conservation and Development Commission (OCC&DC) was created by the 1971 Legislature and charged with studying the natural resources of the coastal zone and preparing a comprehensive plan for the best use of these resources. This inventory was developed by the Soil Conservation Service (SCS) at the request of the OCC&DC.

In January 1971, Governor McCall requested the Pacific Northwest River Basins Commission to form a Federal Technical Advisory Task Force to coordinate efforts of Federal agencies in providing information and assistance to State and local groups engaged in designing a

planning program for the Oregon coastal zone. The Federal Task Force was chaired by a staff member of the Pacific Northwest River Basins Commission and includes representatives from the Departments of Army, Interior, Agriculture, Transportation, Commerce, Housing and Urban Development, and the Environmental Protection Agency.

In June 1972 the OCC&DC chairman directed a letter to the United States Department of Agriculture representative of the Federal Technical Advisory Task Force requesting the Soil Conservation Service, in cooperation with local Soil and Water Conservation Districts (SWCD's), to develop an inventory of all sand dune areas within the Oregon coastal zone. The Commission chairman requested that the inventory identify the following:

1. Active dune areas where development could cause immediate problems.
   a. Foredune areas
   b. Inland dunes of bare sand
   c. Shifting sand spits subject to wind and water erosion
2. Recently stabilized areas.
   a. Those areas stabilized by man (with accurate explanation of how fragile these areas are, if not handled properly)
   b. Those areas of sand that now support stands of shore pine and appear to be stable (with accurate explanation of problems involved unless developed with stringent guidelines)
3. The identification of high surface water table dune sheets where migratory wildlife plantings could be made. The areas are especially important to replace natural feeding grounds lost because of man's interference (homesites, industrial sites, and park sites).

As a result of the above request, the Soil Conservation Service initiated dunes inventory field work in November 1972.

The OCC&DC also requested that Soil Conservation Service resource specialists assist in developing management goals, objectives, and land use policies that were appropriate to beach and dunes resources. Soil Conservation Service biologists, engineers, geologists, agronomists, and soils specialists met with the OCC&DC staff, private sand specialists, and other informed individuals to formulate preliminary resource policies.

On January 28, 1974, the Commission released preliminary policy proposals for beaches and dunes. These policies were a product of the

Commission's action, backed by information gained from participants of 16 public coastal workshops and the assistance of the technical resource team.

PURPOSE AND SCOPE OF THE INVENTORY

The purposes of this report are to: (1) provide resource data for responsible individuals to make wise land use decisions; and (2) provide informational and educational resource data about the dunes environment.

The objectives are to: (1) explain the components of the dune resource which reflect carrying capacity and wise use of the resource; (2) present dune inventory resource maps by county, which can be joined to show a coast-wide resource map; (3) present tabular data showing acreages by dune categories, lengths of dune encroachment, and rates of dune movement; and (4) provide interpretations of the dune inventory mapping units with regard to use.

METHOD OF STUDY

At an early stage in this study the Soil Conservation Service met with members of the United States Forest Service (USFS) Resource Management Team that developed the Resource Inventory Report for the Oregon Dunes National Recreation Area (36).[1] Extensive discussions were held with members of the USFS Resource Management Team about sand dune mapping units selected in the NRA study. In addition, by using two Delft Scanning Stereoscopes sand dune maps for the NRA study were simultaneously examined by members of the USFS Resource Management Team and the Soil Conservation Service. This procedure resulted in meaningful dialogue about sand dune mapping unit characteristics, and desirable land use.

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[1]The Oregon Dunes National Recreation Area will be abbreviated NRA throughout this report.

An extensive evaluation was made of several types of aerial photos for use as a base for the study. Because of the coast-wide scope of the study it was decided to use available color aerial photos with a scale of one inch equalling one mile. Selection of a larger scale would have greatly increased field checking time. In addition, the available flight was relatively recent (May 10, 1971) which eliminated the time delay and cost of new photography. Color prints were selected because they facilitated better aerial photo interpretation. For example, new beachgrass plantations can be readily recognized on the color flights, whereas these plantations are often indistinguishable from open sand areas on equivalent black and white prints.

Once the photo selection process was completed, a tentative mapping legend was established. In the NRA study 40 mappings units were used. These mapping units were reduced to 20 because of the coast-wide scope and small scale of this study. Two mapping units: active foredunes and older stabilized dunes were added. These types of dune features were mapped in the NRA study and included with other units.

Preliminary mapping was done with a steroscope. This was followed by field mapping conducted on a county by county basis. The county field mapping was reviewed with the SCS District Conservationist and other members of his staff. In addition, the field mapping was reviewed with SWCD Boards of Supervisors and other knowledgeable people.

STATUS OF DUNES RESEARCH

One of the most significant contributions to the subject of sand dunes stabilization is USDA Circular 660 by McLaughlin and Brown (21). This early paper discusses the (1) extent and location of dunes along the Pacific northwest coast; (2) need for stabilization control; (3) history of control in Oregon; (4) causes of coastal dunes; and (5) methods of control. The vegetational control section discusses where, when, what, and how to plant. Mechanized procedures now partially supersede the hand procedures described (21) and new plant varieties are available. Therefore, the number of separate seedings and transplantings needed to obtain permanent stabilization has been reduced, but the basic procedures described by McLaughlin and Brown are still applicable, for equivalent areas.

Companion publications to USDA Circular 660 are those by Brown (7) and Brown and Hafenrichter (8). Brown's paper discusses coastal dune stabilization field trials using legumes seeded with grass

mixtures and associated fertilizer applications. Brown (7) anticipated the recommended procedure would reduce the transition period from denuded sand to permanent stabilization, from five to two years. Brown and Hafenrichter (8) discuss the results of field trials using shrubs for intermediate and auxiliary stabilization. The shrubs were introduced after sand-stilling grasses became established and sand disposition decreased. Some of the shrubs described not only have a sand-stilling effect but also restrict traffic to prescribed areas, provide a fire break in tree plantings, and provide a nitrogen source which assists in establishment of permanent vegetation.

Cooper (11) describes the Oregon and Washington coastal dune environment in considerable detail; his work includes: (1) a history of dune forms on the Oregon and Washington coast; (2) a description of 30 dune localities; and (3) an analysis of dune forms and processes.

Wiedemann, Dennis, and Smith (40) give a thorough description of plants and plant communities of the Oregon coast and include a taxonomic key to 90 plants that are commonly associated with the dunes. The book is readable and common names are used with scientific names in parentheses.

A USFS resource planning team developed a comprehensive resource inventory report for the Oregon Dunes National Recreation Area (36). This report represents the product of detailed resource data collection and identifies major geomorphic-plant community types. These were delineated on large scale maps, and management interpretations or predictions were developed.

Schlicker, Deacon, Olcott, and Beaulieu (27, 28, 29) discuss beach, dune and spit areas in their Environmental Geology Reports. They address some construction hazards in dune areas and point out that sand spits and their active dunes are of recent origin and should be viewed as temporary features.

Lund (20) discusses some dune landforms described by Cooper (1) that occur along the central Oregon coast in a readable, illustrated form.

The recent U.S. Army Corps of Engineers Coastal Reconnaissance Study of Oregon and Washington (35) presents excellent information about coastal landforms, including beaches and dunes. Thirteen sites in Oregon were surveyed and described in terms pertinent to land use, open space, historical, and archaeological features, as well as recreation and wildlife uses. Since all dune mapping units used in this report have recreation and wildlife uses, the reconnaissance study is an excellent companion study of specific dune sites.

STUDY AREA SETTING

The beaches and dunes of the Oregon coast are relatively recent geologic features. By tracing the processes which have acted upon the coastal landscape through time, climate, geology, soils, plant succession, marine influences, and human settlement, the dynamic nature of these beaches and dune systems can be better understood.

The descriptions which follow will provide general background information on the coastal environment as well as a discussion of regional differences. This perspective is a key to effective long range management of Oregon's beaches and dunes.

CLIMATE

Climate exerts a major influence on physical and biological processes involved in beach and dune development and persistence. Temperature (Table 1), precipitation, humidity, cloud cover, fog, and wind (Plate 1) affect sand movement and vegetation patterns, both of which are critical components of dune systems. Marine influences modify climatic conditions, especially on the immediate coastal strip where beaches and dunes occur.

The climate in Oregon's coastal zone is mild with small seasonal variation in temperature. Mean temperatures for January range between 41 and 47 degrees F., and between 57 and 61 degrees F. for July (see Table 1). Winters are wet and cool and the coastal fog, which occurs in the warmer months,[2] reduces the moisture loss which would otherwise occur during the dry summers.

Winds are generally from the northwest during the summer and from the south, southeast and southwest during the winter (see Plate 1). Along the central Oregon coast there are low velocity offshore east winds during January. In addition, as indicated on Plate 1, stations with large percentages of low velocity southeast

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[2]The coastal fog belt is the result of cool marine air masses being heated and forced upward.

TABLE 1. CLIMATOLOGICAL SUMMARY FOR COASTAL SITES

(MEANS OF EXTREMES)

Station Location	Temperature (°F)							Precipitation					
	January			July									
	Mean Daily Max.	Mean Daily Min.	Mean Monthly	Mean Daily Max.	Mean Daily Min.	Mean Monthly	Mean Annual	Maximum Months	Monthly Rain-fall (Inches)	Minimum Months	Monthly Rain-fall (Inches)	Total Annual Rain-fall (Inches)	Precip-itation 0.10 inch or more (days)
Astoria	48	35	41	68	53	61	51	Dec.-Jan.	11-14	July Aug.	1.0-1.5	80	199
Tillamook	49	34	--	70	50	--	--	Dec.-Jan.	13-15	July Aug.	1.0-1.5	89	---
Newport	50	37	44	65	50	57	51	Dec.-Jan.	10-11	July Aug.	0.8-1.0	66	124
North Bend	52	38	45	68	51	59	52	Dec.-Jan.	10-11	July Aug.	0.4-0.5	62	107
Brookings	54	40	47	66	50	58	53	Dec.-Jan.	13-14	July Aug.	0.6-0.9	81	104

This Table was provided through the courtesy of the Portland District, Corps of Engineers.

This Plate was provided through the courtesy of The Portland District, U.S. Army, Corps of Engineers.

PLATE I. JANUARY AND JULY WIND ROSES FOR SELECTED SITES

winds for January occur on the central and south coast. The Oregon coast receives the full force of storms that move inland from the Pacific Ocean. This results in heavy precipitation and winds potentially exceeding hurricane speeds (74 mph and over) during the winter (35). Winds along the coast can be expected to reach 90 to 100 mph once in a hundred years.

As air masses move inland from the ocean most of their moisture is released as they rise over the Coast Range and Klamath Mountains. The rains and cloudiness of late fall, winter, and early spring are caused by moist marine air masses encountering the mountains and the relatively cooler land surface. Snow and heavy freezes are rare. Rainfall is higher and temperatures tend to be cooler further inland near the western slopes of the mountains.

GEOLOGY

In the Oregon coastal zone, beaches and dunes are associated with Teritiary and Pleistocene sedimentary and volcanic rock of the Coast Range and older pre-Tertiary metamorphosed material of the Klamath Mountains (see Plate 2). During the Eocene period (38-54 million years ago), a shallow sea resting within a geosyncline basin[3] covered the entire state west of the Cascades with the exception of the Klamath Mountains.

As the Klamath Mountains uplifted, erosion increased adding arkosic[4] sediments to the volcanic deposits within the basin. Volcanic activity persisted throughout the Eocene so igneous materials frequently interbedded with sedimentary layers. By the late Eocene (45 million years ago), tuffaceous silts, sediments of volcanic origin, and clays rich in organic matter, began to be deposited by streams and rivers flowing from the surrounding highlands. Vast quantities of arkosic sediments were deposited in the basin during Oligocene times (26-38 million years ago). This was followed by a resugence in volcanic activity during the Miocene when intrusions formed basaltic headlands and peaks; the uplift of the Coast Range reached its greatest height about 12 million years ago. Rapid

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[3] A downward flexure in the earth's surface associated with mountain building processes.

[4] Sediment derived from rapid decomposition of acid igneous rocks like granite which have a granular texture.

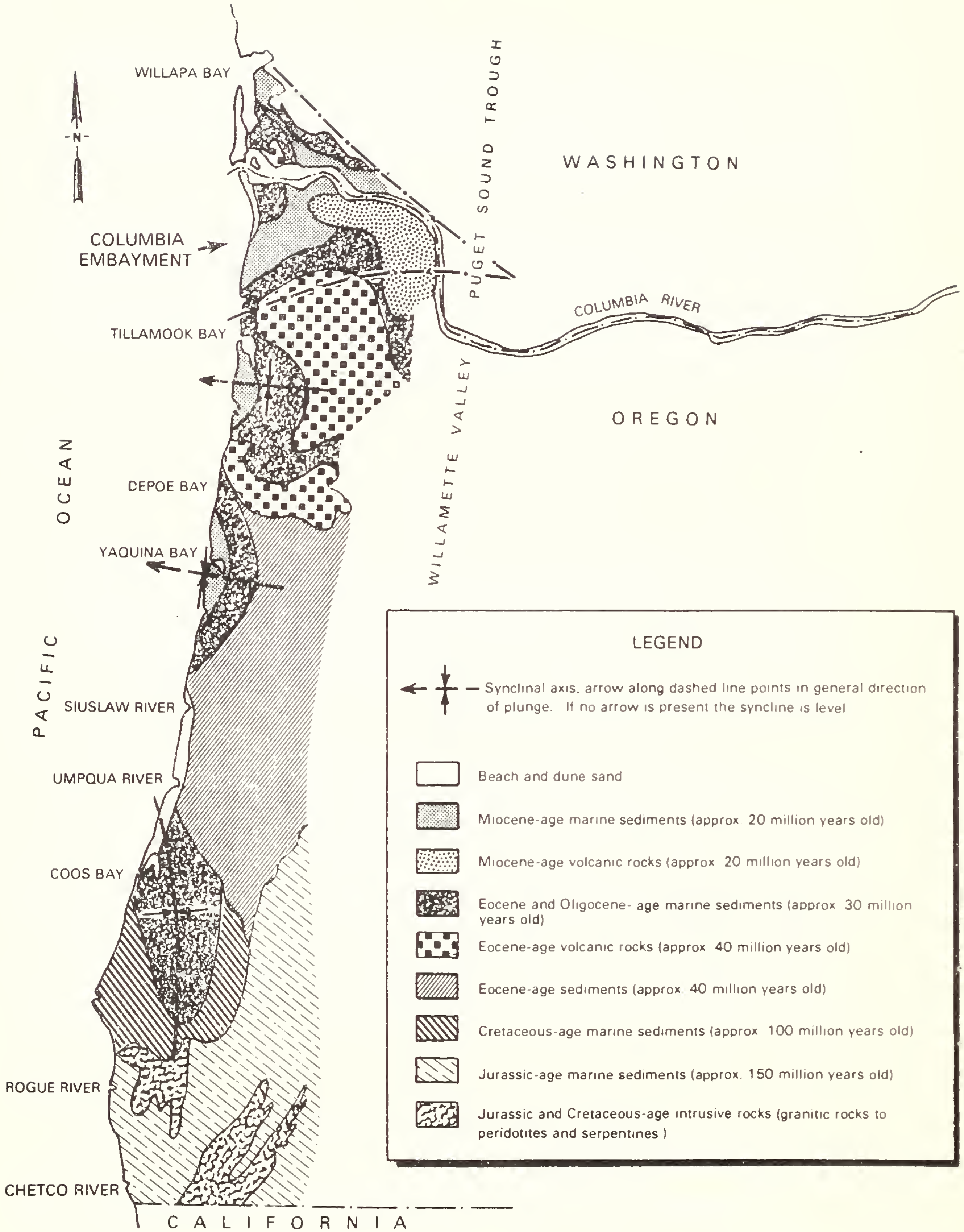

PLATE 2. GENERALIZED GEOLOGY IN KEY AREAS, PACIFIC NORTHWEST COAST

This Plate was provided through the courtesy of The Portland District, U.S. Army, Corps of Engineers.

erosion of sandstone continued through the Pliocene and Pleistocene periods and beginning about a million years ago there were extreme fluctuations in sea level associated with the continental glaciation cycles.[5]

There have been two major episodes of sea level fluctuation which have influenced existing features in coastal landscape. The period of great submergence was followed by a period of slight emergence. According to Cooper (11), prior to submergence a sloping coastal plain flanked mountain front and parallel ridge dunes. This coastal plain formed an almost continuous strip along the entire coast, and the shoreline stretched beyond what would later be the rocky headlands. As the sea advanced a series of coastal terraces was created, and the shoreline became more irregular due to varying degrees of resistance to erosion. The drowned valleys of coastal rivers and streams, predecessors of today's estuaries, formed sandspits and bars at their mouths as sediments began to accumulate. Sand dunes traveled further inland as sea level rose. Lakes were created as the dune advance dammed small stream valleys. Since the time of maximum submergence, there has been a slight uplift of the coast which is associated with the familiar 150 foot terrace of the Oregon coast. "Along the open sea there were cliffs separated from the shore by barrier beaches with lakes and bays behind them and forested wave-cut cliffs fronting terraces and dune masses with wide beaches below (i.e., Regions 2 and 3 as described by Cooper). On the bay shores of bars and peninsulas, gently sloping aprons merged with the tidal flats and dune ridges." (11, p. 132).

According to Cooper (11) there has been a fundamental difference in the development of shoreline features north and south of Tillamook Head; the Clatsop Plains to the north began to form at the base of wave-cut bluffs following the period of maximum submergence. In contrast, the dunes on the rest of the coast had already reached their furthest advance prior to the end of submergence. Shoaling of vast amounts of sand at the mouth of the Columbia River allowed the outward extension of the shoreline in series of ridges which eventually formed a broad peninsula. Areas further from the mouth do not extend out as far because the available sand supply is reduced and the longshore currents have a stronger influence. Following construction of the south jetty on the Columbia River in the late 1800's there has been out-building from the peninsula. South of Tillamook Head, the inland advance of the dunes was halted by stabilization before the end of the submergence, although undoubtedly there were episodes of reversal and geographic variations. These stabilized dunes have been subject to marine erosion throughout the area south of Tillamook Head.

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[5]As the continental ice sheets melted there was a rise of sea level followed by a lowering as the climate cooled again.

In these last 3000 to 6000 years since maximum submergence, the shoreline has remained essentially stable. However, beach and dune sediment has accumulated in the Clatsop Plains area; the central and south coast (Regions 2 and 4 of Cooper, 11) have experienced slight to severe erosion; and there has been relative stability along the shoreline of the Coos Bay dune sheet (Region 3 of Cooper, 11).

Rocky headlands characterize many parts of the Oregon coastline and give it much of its scenic appeal. On the northern shoreline they are predominantly basaltic, sedimentary and metamorphic rocks dominate in the central and south coast. Tillamook Head, Cape Falcon, Cape Measres, Cape Lookout, Cascade Head, Cape Foulweather, Heceta Head, and Yaquina Head are basaltic formations, while Cape Arago, Coquille Point, Cape Blanco, and the remaining headlands to the south are sedimentary and metamorphic formations. These differences in headland composition are the result of the subsiding coastline to the north. The wave action in this area has stripped away the soft sedimentary rocks and exposed the resistant volcanic rocks. Southward the rising coastline results in planation or coastal terrace cutting so that all rock types are uniformly bevelled (35).

Where headlands project sufficiently westward, they deflect the longshore currents (see Plate 3) seaward. These offshore currents transport and deposit sediment and are associated with seasonal wind regimes. During the summer the south-flowing California current (see Plate 3) is close to shore, but winter upwelling disrupts to such an extent that only the more distinct north-flowing Davidson current has significant influence. During the winter, storms erode the coast and the Davidson current transports large quantities of sand northward. Summer wave action slowly rebuilds the beach with sediment transported to the ocean by coastal streams. Generally, sediments are transported southward along most of the coast (19 and 23) during the summer. However, past investigation indicates a predominantly northward transport of Columbia River sediment (12).

The relationship between the Columbia River and the Clatsop Plains on the north coast, and the Siuslaw and Umpqua Rivers and the Coos Bay dune sheet on the south coast, evidences the importance of coastal rivers as a sand source. In the case of these two regions, the sediment deposited so greatly exceeds the amount removed by longshore transport that dune formations are extensive. However, headlands, stream mouths, and jetties interrupt longshore transport of sand, thereby causing localized deposition. In some cases, a major interruption, such as a series of headlands, isolates sections of the shoreline, and littoral drift is essentially contained within the barriers. The relationship between local sand quarry areas and streams, and the beaches and dunes which are sustained by these sand supplies is sometimes critical.

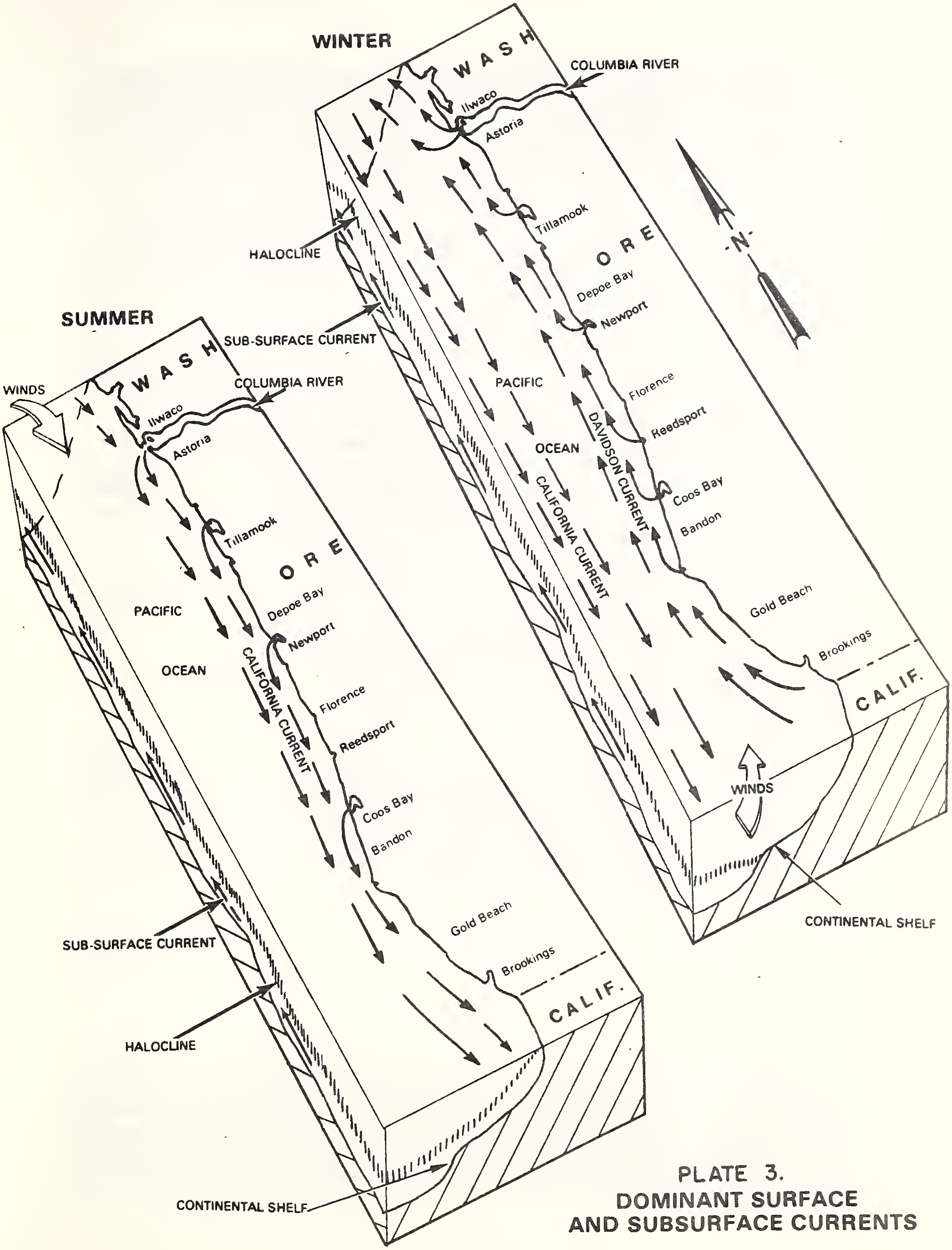

PLATE 3.
DOMINANT SURFACE
AND SUBSURFACE CURRENTS

This Plate was provided through the courtesy of The Portland District, U.S. Army, Corps of Engineers.

The sand supply for some beaches and sand dunes of the Oregon coast can be understood when the locations of black sand deposits are examined. The black sands of the Oregon coast are considered to be derived from the Klamath Mountains (11, 14 and 32) on the south coast. They were distributed northward from the mouths of the southern Oregon rivers by the Davidson current, and have been found in commercial quantities as far north as the south end of Coos Bay. It has been noted (35) that if the California current dominated the Davidson current, then the accumulation of large quantities of black sand would only occur south of the Coquille River, because major source areas lie south of this river.

The importance of the south coast as a source of sand is further shown in the study by Twenhofel (32). He concludes that the majority of the existing dunes are composed of arkosic sand which was derived from the Klamath Mountains in a period prior to submergence. Twenhofel's investigations of dune sands along the Oregon coast demonstrate that in nearly 90 percent of the analyzed samples, by weight 97-100 percent of the sand particles consisted of sizes ranging from 1/2 to 1/8 millimeters. Mineralogically, this study found that the sands were 71-91 percent quartz and feldspar, with the remaining particles being mostly rock fragments. On the other hand, the beach sand studied occasionally showed high concentrations of heavy minerals with high specific gravities of 4.6 to 5.2 in comparison to quartz and feldspar with 2.6. These heavy minerals, the black sands mentioned previously, have accumulated on beaches. Where high concentrations of heavy minerals are found in sand dunes, it could be interpreted that the site existed for a time as a beach, or near a beach sand supply.

The Oregon coast lies within the circum-Pacific earthquake belt and is therefore subject to tsunamis (seismic sea waves) which have had catastrophic effects on the coast in the past. Seismic sea waves, generated by the 1964 Alaskan earthquake, struck the Oregon coast with waves that reached a maximum height of 10 feet above mean high water at Yaquina and Coos Bays (26).

SOILS

Soils of the Oregon coast beaches and dunes vary from sparsely vegetated sandy beach deposits, or active dune land, (37) to forested, well-developed Blacklock soils that are on old beach deposits and old sand dunes of present marine terraces. The most commonly occurring beach or dune soils along the Oregon coast are the Westport and Netarts series.

Typical Westport soils are formed in recently stabilized slightly weathered dune sand and have thin, very dark grayish brown A1 horizons, dark grayish brown fine sand AC horizons, and olive gray fine sand C horizons. The Westport series is a member of the mixed, mesic family of Typic Udipsamments.

Typical Netarts soils are formed in old stabilized dunes and have black fine sandy loam A1 horizons; distinct, light colored loamy fine sand A2 horizons; and variegated fine sand Bir horizons with weakly cemented nodules and lenses. The Netarts soil series is a member of the sandy, mixed mesic family of Entic Haplorthods. This series is commonly seen in near-vertical road cuts along U.S. Highway 101. These areas show the dark surface, underlain by cemented narrow red and yellow bands in the subsoil.

Other soils that commonly occur are on youthful or old beaches and dunes are Bandon, Blacklock, Bullards, Ferrelo, Heceta, and Nelscott. Most have limited agricultural value, but some soils, such as Bandon, Bullards, and Blacklock are utilized for pastureland. Blacklock soils also are used for cranberry bogs.

VEGETATION

Natural plant communities of the Oregon coastal zone reflect the moderate climate of the region. Within the immediate coastal strip and fingering inland along the river valley bottoms, environmental conditions are conducive to the growth of lush coniferous forests. This area, described by Franklin and Dyrness (13) as the Sitka spruce *(Picea sitchensis)* zone, is characterized by frequent summer fogs and the most uniformly mild and humid climate in the state. It is within this vegetation zone that all coastal beaches and dunes occur. Vegetation plays an essential role in the development of these shoreline features. If the dense coastal forests did not exist, then the dunes would advance inland unhindered and drift high on the slopes of the mountain front, as they do on the arid coasts of Chile and Peru (11).

Plant communities operate in direct opposition to the wind by stilling the sand and stabilizing the surface. Their contribution to soil formation indirectly modifies the wind because it sets the stage for further stabilization. Given the advantage of an extended growing season and abundant moisture, plants which can tolerate abrasion, desiccating salt spray, and sand burial colonize active sand areas. Following the initial pioneer species, plant succession continues

unless interrupted by new dune movement. Natural vegetation in dune areas is diverse and highly dynamic; plant succession occurs rapidly and the full progression from open sand to forest is visible within a small distance.

Prior to introduction of European beachgrass in the late 1800's (36), the familiar foredune and deflation plain near beaches on the Oregon coast did not exist. There was no native plant which could tolerate the shoreline wave attack. On a receptive shoreline, the wind transported sand from the beach directly inland to nourish dune migration. Sites protected from wave action were vegetated by native grasses, rushes, and sedges, notably American dune grass *(Elymus arenarious)* and bigheaded sedge *(Carox macrocephala)* (40). Later stages in succession closely paralleled the forest and shrub communities which exist today. It was not until well after 1930 that European beachgrass became widespread. Colonizing hummocks coalesced to form a continuous active foredune or foredune just beyond the level of high tide.

Ericaceous[6] shrub communities occur in plant succession after beachgrass communities. The ericaceous shrub communities contain wax myrtle *(Myrica californica)*, rhododendron *(Rhododendron macrophyllum)*, manzanita *(Arctostaphylos columbiana)*, and kinnickkinnick *(Arctostaphylos ura-ursi)* and are dominated by the ubiquitous salal *(Gaultheria shallon)*.

Wind currents scour the area directly behind active foredunes to the water table. This creates the wet deflation plain, a belt of low wetland, which has been rapidly colonized by carex, rushes, and willows. Wet deflation plains and other wet dune areas, such as dune lakes also generate dense shrub communities which include coastal willow *(Salix hookeriana)*, red alder *(Alnus rubra)*, Labradortea *(Ledum glandulosum)*, Douglas spiraea *(Spiraea douglasii)*, and twinberry *(Lonicera involucrata)*. The transition from shrub to forest communities is rapid (36).

Shore pine *(Pinus contorta)* joins spruce in the deflation plain and replaces it on sites with less moisture, such as dune ridges. For the most part, shore pine is a pioneer species associated with fire and dune activity; therefore, if conditions remain wind stable, longer lived species, such as spruce, become dominant. Douglas fir *(Pseudotsuga menzesii)* occurs in areas protected from coastal winds. Western hemlock *(Tsuga heterophylla)* and

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[6]Ericaceous species are all in the Heath family and have thick, leathery, evergreen leaves well adapted to withstanding dry summers, desiccating salt spray, and well drained soils.

western red cedar *(Thuja plicata)* are associated with spruce in the older stands and wetter sites. Port Orford ceder *(Chamaecyparis lawsonians)* acts as pioneer species in southern Oregon forests (13). The forest understory varies with environmental conditions, age of the stand, available moisture, and degree of crown closure. Generally rhododendron, wax myrtle, and evergreen huckleberry *(Vaccinium ovatum)* are the most common (36).

HUMAN INFLUENCE

Man's activities have had a profound effect on the shoreline of the Oregon coast by directly or indirectly causing acceleration or renewal of dune activity and shore erosion. In addition, measures taken to protect property and structures have also significantly altered the landscape in a short time. Coastal Indian habitation sites along the shoreline and in dune areas evidence the suitability and importance of these areas for human settlement. These first coast dwellers had little long range impact on the natural environment, other than increasing the frequency of fires. About 200 years ago a tremendous fire occurred from Yaquina Bay to an area south of Coos Bay. Coos Bay was filled 12-14 inches deep with a layer of ash, and the native oyster industry was wiped out. Most of the significant changes in the coastal landscape have occurred within the last 100 years.

During early white settlement, man-caused forest fires were widespread, but the damage was far exceeded by later activities. Mining, logging, and land clearance for cultivation choked coastal rivers with sediment and greatly accelerated the filling of the estuaries. In 1851, McKee found that the Klamath Indians were starving because tons of mining debris killed most of the fish in the streams (6). Logging practices indirectly effected the shoreline and dune areas by increasing the sediment loads deposited by coastal streams and the number of drift logs on the beaches. Timber harvest has not been extensive in dune areas because the trees were generally of low commercial value. Grazing, long a practice in the low wet areas of the Coos Bay dune sheet and Clatsop Plains, has been responsible for extensive rejuvenation of sand activity. Over-grazing and breaching of the dunes by construction and animal trails in the Clatsop Plains destroyed much native herbaceous cover as well as planted trees used to stabilize the dunes. This created an extensive area of active sand movement. Active dune development is also associated with jetties. At the mouth of the Columbia, sand accumulated behind the jetty so rapidly that the dunes did not have sufficient time to become vegetated.

Control of dune activity and the introduction of European beachgrass have generated far-reaching effects on the Oregon coastal landscape. Between 1910 and 1935, a series of small sand stabilization projects were initiated on the Coos Bay dune sheet utilizing European beachgrass and various species of shrubs and trees. In 1935, the Soil Conservation Service and the Civilian Conservation Corps (CCC) began a comprehensive sand stabilization project on the Clatsop Plains. Some 3,000 acres of actively blowing sand were systematically stabilized in a progression which essentially duplicated natural plant succession. Artificial barriers and resistant grasses were used to still the sand and begin the formation of the dune. Scotch broom *(Cytisus scoparius)* was added to fix nitrogen and provide cover and organic material for later plantings of other shrubs and trees. The success of this large scale effort provided both technical information and an incentive to the stabilization projects which followed. When active dunes threaten highways, railroads, navigation, major developments, or structures, artificial stabilization has been used as a management tool.

An unforeseen result of these efforts was that European beachgrass naturalized and began to form a continuous foredune along the sand areas of the coast. The wind's baffling effects on the foredunes halted the inland movement of sand from the beach and helped create the wet deflation plain. Documentation from aerial photographs demonstrates how quickly these changes have occurred. South of the Siuslaw River there were only a few clusters of vegetation near the beach and no evidence of a foredune in 1941 (36). Thirty years later, a fully developed foredune and a 1/4 mile wide deflation plain were visible in the same area. Similarly, a deflation plain further south, which is close to an early stabilization project, has doubled in width every ten years since 1952 (36).

Early travelers utilized the open sands of the coast as travel routes. Most towns along the immediate coastline have either been built on older naturally stabilized dunes or are associated with isolated dune remnants on coastal terraces or lakes. Today's active dune areas are used extensively for recreation. Hiking, camping, hunting, and driving off-road vehicles are popular pastimes in the dunes.

The Oregon Dunes National Recreation Area was established by Congress in 1972 to protect the natural scenic, historic, and recreational values of a section of the Coos Bay dune sheets stretching inland one to one and one-half miles along 40 miles of shoreline. The NRA includes massive dunes of every type except the parallel foredune ridges of the Clatsop Plains.

Water extraction for domestic and industrial purposes is a relatively recent activity and has not as yet caused excessive adverse effects. However, future management must ensure that the water table

will remain at a level sufficient to provide moisture to sustain protective vegetative cover. Otherwise, dune movement could be reactivated. It is believed that excessive drawdown of the water table at the Bay Ocean community contributed to the massive erosion of the Tillamook spit.

Breakwaters, riprap, and jetties have been established on the ocean shoreline to protect property and navigation channels. These structures effect patterns of shoreline erosion, transport, and accretion to varying degrees. Jetties have been constructed at the mouths of most of the major coastal rivers, beginning with the Columbia before the turn of the century. They have caused increased sand deposition along Oregon's beaches at several locations. These jetties, along with unjettied river mouths and rock headlands, appear to interfere with the longshore transport of sands, which results in an uneven distribution of sand along the coast, and an increasingly shorter supply of sand.

BEACHES AND DUNES IN THE COASTAL ENVIRONMENT

Extensive beach areas have developed along the Oregon coast, but they are discontinuous because of the ruggedness of the shoreline. Along the more continuous Oregon beaches, beachgrass or other plants advance to the normal storm tide line where their encroachment is halted by wave action. As the greater part of the sand movement along the north Pacific coast takes place during high velocity winter storms, it is during this period that beach sand engulfs the vegetation along the shoreline (21). During the spring and summer, vegetation can grow up through the sand and form a lush growth that can be covered with sand again during the following winter. A foredune develops by this process.

Sand dunes occur irregularly along the Oregon coast. Of the 314 miles of ocean-facing coastline, 195 miles or 62 percent contains dunes. As shown in Table 2, there are about 17,700 acres of open sand dunes; 4,920 acres of open sand dunes conditionally stable; 14,945 acres of younger stabilized dunes which are semi-permanently stabilized by shrubs and shore pine; and 80,855 acres of older stabilized dunes and associated former beaches, which are permanently stabilized by Sitka spruce, western hemlock, Oregon crabapple, and Douglas fir. Collectively, there are 125,400 acres of sand dunes and 38,980 acres of associated wet areas along the Oregon coast.

The dune mapping units were combined into three associations for discussion: active dunes, recently stabilized dunes, and older stabilized dunes; the extent and distribution of these associations are summarized on Table 2A.

ACTIVE DUNES

Active dune landforms include transverse dunes, oblique dunes, parabola dunes, active dune hummocks, and active foredunes. For the purposes of this inventory, several dune forms were grouped under the open dune sand category whose mapping symbol is OS. This open dune sand category includes transverse dunes, oblique dunes, and parabolas. Soil interpretations for active dunes are given in the Soil Interpretations Appendix.

TABLE 2

MAPPING UNITS

NAME OF COUNTY	DC Acres	DS Acres	FD Acres	FDA Acres	H Acres	IFD Acres	ODS Acres	OFD Acres	OS Acres	OSC Acres	W Acres	WDP Acres	WFP Acres	WMF Acres	WSP Acres
Clatsop	-	250	250	200	-	250	20	1,120	160	110	9,145	4,750	4,305	420	1,075
Tillamook	135	2,745	325	730	145	-	1,700	-	1,170	1,275	1,025	450	14,350	1,100	14,600
Lincoln	-	1,320	385	100	-	-	11,220	-	115	415	755	50	3,630	430	8,445
Lane	735	2,670	395	30	75	-	5,305	-	4,315	1,320	5,485	1,995	930	50	485
Douglas	225	1,710	385	135	225	-	1,760	-	4,035	95	460	2,135	2,460	95	4,805
Coos	200	4,475	130	95	220	-	40,465	-	7,295	315	5,620	5,820	8,085	200	12,710
Curry	110	1,775	185	95	-	-	20,485	-	610	1,390	1,205	85	8,210	-	930
TOTALS	1,405	14,945	2,055	1,385	665	250	80,955	1,120	17,700	4,920	23,695	15,285	41,970	2,295	43,050

DC - Dune complex of OS, OSC, DS, and W
DS - Younger stabilized dunes
FD - Recently stabilized foredunes
FDA- Active foredune
H - Active dune hummocks
IFD- Inland foredune
ODS- Older stabilized dunes

OFD - Older foredune
OS - Open dune sand
OSC - Open dune sand conditionally stable
W - Wet interdune
WDP - Wet deflation plain
WFP - Wet flood plain
WMF - Wet mountain front

TABLE 2A

SAND DUNE MAPPING UNITS AND DUNE FORMS

ASSOCIATED DUNE CATEGORIES	MAPPING UNIT		ABBREVIATED DESCRIPTION
	NAME	SYMBOL	
Active Dunes	Open Dune Sand	OS	Wind drifted sand in the form of dunes and ridges, that are essentially bare of vegetation.
	Active Dune Hummocks	H	Partly vegetated circular and elevated mounds of sand.
	Active Foredunes	FDA	A growing barrier ridge of sand paralleling the beach which lies immediately above the high tide line.
Recently Stabilized Dunes	Foredunes	FD	An active foredune that has become conditionally stable with regard to wind erosion.
	Open Dune Sand Conditionally Stable	OSC	A sand dune presently in wind stable condition but vegetated by fragile plantings.
	Dune Complex	DC	Various patterns of small dunes with partially stabilized intervening areas.
	Younger Stabilized Dunes	DS	A youthful wind stable dune landform.
Older Stabilized Dunes	Older Stabilized Dunes	ODS	A wind stable dune landform that has soils with weakly cemented nodules and lenses to strongly cemented nodules or strongly cemented Bir horizons.
	Older Foredunes	OFD	A wind stable former foredune landform that lies approximately parallel but back away from the beach.

Open Dune Sand (OS)

In the absence of vegetation, dunes operate only in response to sand supply and wind, as is the case of desert sand dunes. Open dune sand areas exhibit some of the same characteristics as desert sand dunes and are defined as wind-drifted sand in the form of dunes and ridges which are essentially devoid of vegetation.

On the Oregon coast, active open dune sand areas advance onto forestland, pastureland, cropland, roads, railroads, lakes, and stream channels, and endanger residential, commercial, and industrial property (see Figures 1-8). Yet, at the same time many open sand dunes have tremendous aesthetic and recreational importance. These areas can be highly dynamic; Figure 1 shows the positions of an active dune along the west and south edge of Cleawox Lake during 1936, 1941, 1952, 1961, and 1972. This dune is currently moving into Cleawox Lake at Honeyman State Park at an average annual rate of 0.16 acre per year. It lacks about 150 feet (see Figure 5) to bisecting and closing the outlet of the upper lake. Figure 2 shows several active open dune sand areas. The dune shown at A is encroaching on the Florence Airport. The dune shown at F is sloughing into the Siuslaw River (Figure 6).

The leading edge of open dune sand is generally referred to as a precipitation ridge. Precipitation ridges are shown in the generalized sand dune profiles presented as Figures 3 and 4. Precipitation ridges are shown moving into Cleawox Lake in Figure 5, Siuslaw River in Figure 6, an interdune area in Figure 7, and onto a road in Figure 8.

Transverse Dunes (included in OS)

The transverse dunes have low relief and are composed of a sloping ridge and a slip face. The wave-like pattern of these dunes (see Figures 3 and 4) is partly destroyed in the winter due to wind direction changes, but reforms again during the summer. Some transverse dunes have summer water tables because of their proximity to wet deflation plains. Small transverse dunes are shown on the windward side slope of the high dune sketched in Figure 3.

In terms of use characteristics, transverse dunes do not support a plant community and are only used by wildlife when traveling to and from adjacent areas (36). However, in many areas transverse dunes are the standard against which all other landforms are visually

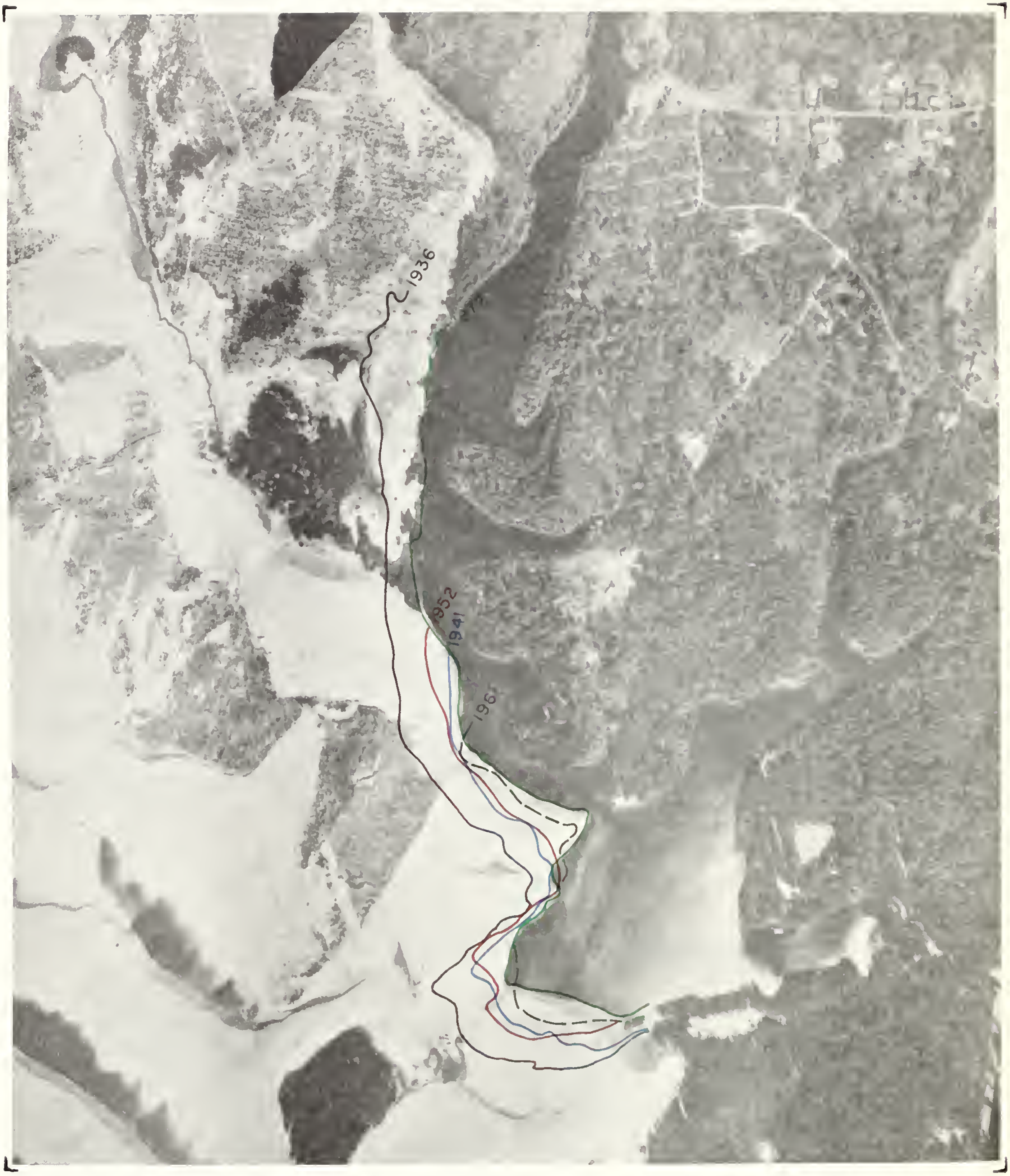


FIGURE 1
DUNE MOVEMENT CLEAWOX LAKE
LANE COUNTY, OREGON

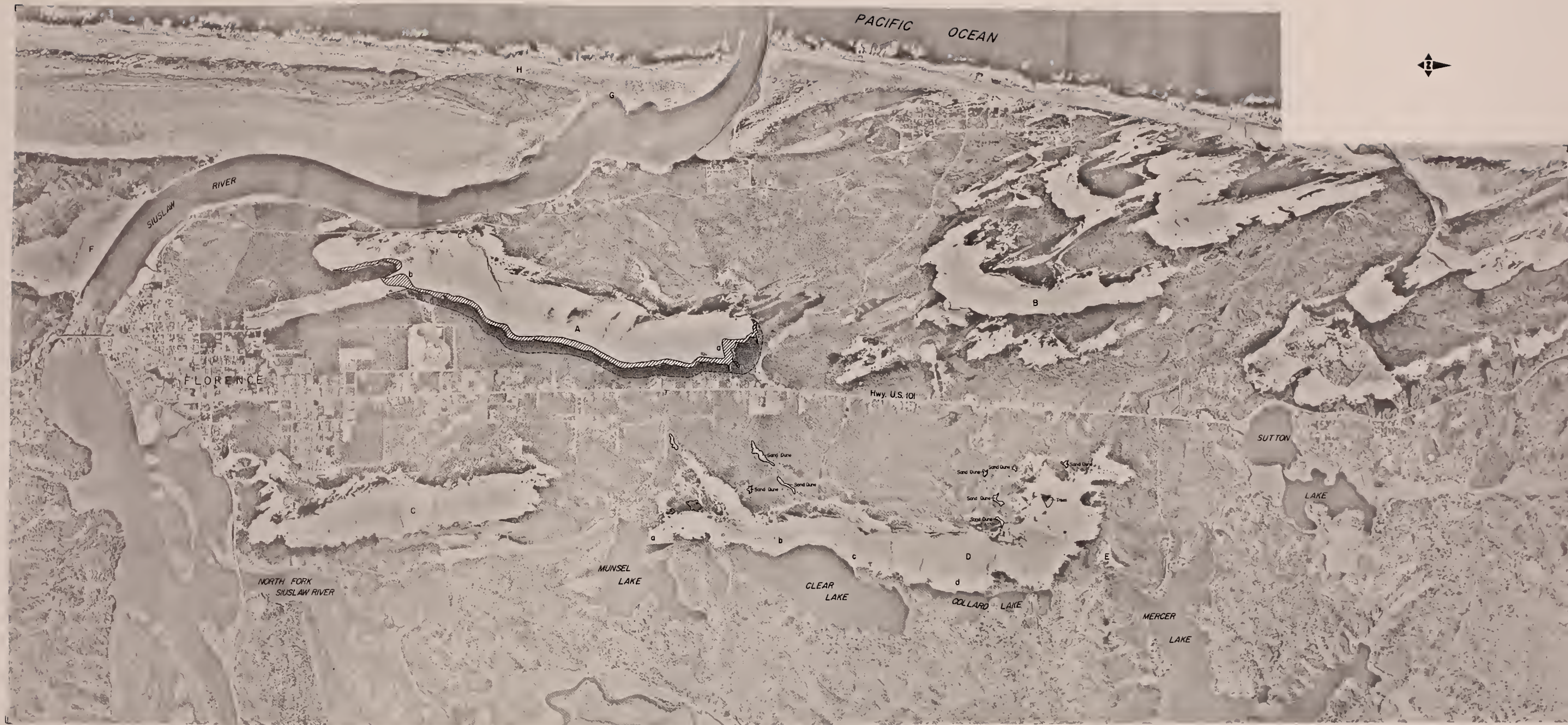
AUGUST 1974

PHOTO BASE 1972

800 0 800 1600 FEET

SCALE 1:9600

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1974



LEGEND

Dune encroachment 1952 - 1972

Projected dune encroachment 1972 - 2020

A. Airport dune
   a. Northeast corner
   b. Airport blowout
   c. Beaver Stream
B. Heceta dune
C. Drew cemetery/dune
D. Clear Lake dune
   a. Munsel Lake
   b. Water tower planting
   c. Central Clear Lake
   d. Collard Lake
E. Mercer Lake Parabola
F. Siuslaw River dune encroachment
G. Siuslaw River streambank cutting
H. Siuslaw River spit foredune undercut

FIGURE 2

FLORENCE AREA SAND DUNES

LANE COUNTY, OREGON

AUGUST 1974

1/2 1/4 0 1/4 1/2 3/4 1 MILE

SCALE 1:31,680

Photo Base March 29, 1972

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

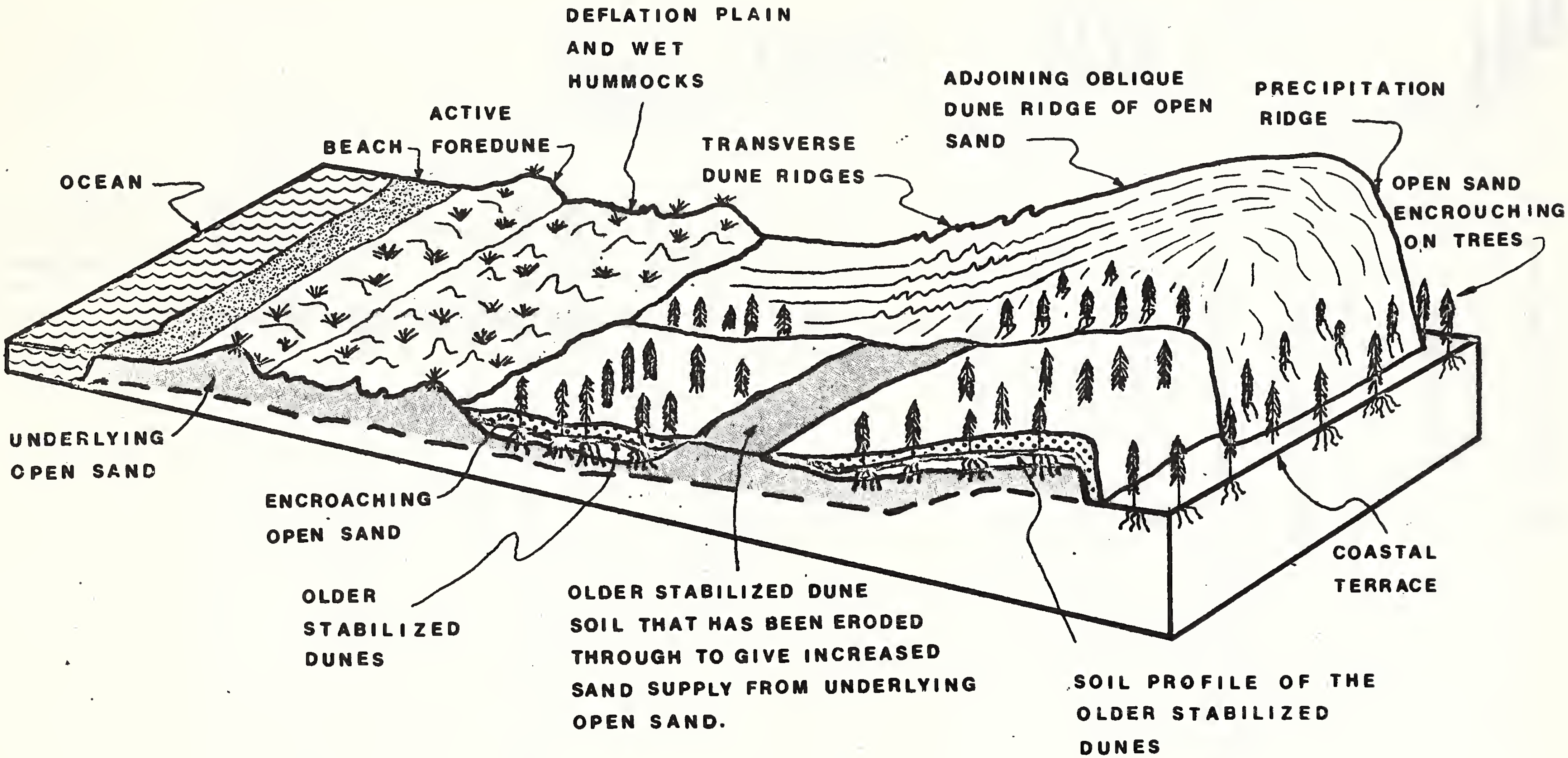


FIGURE 3 – GENERALIZED SAND DUNE PROFILE

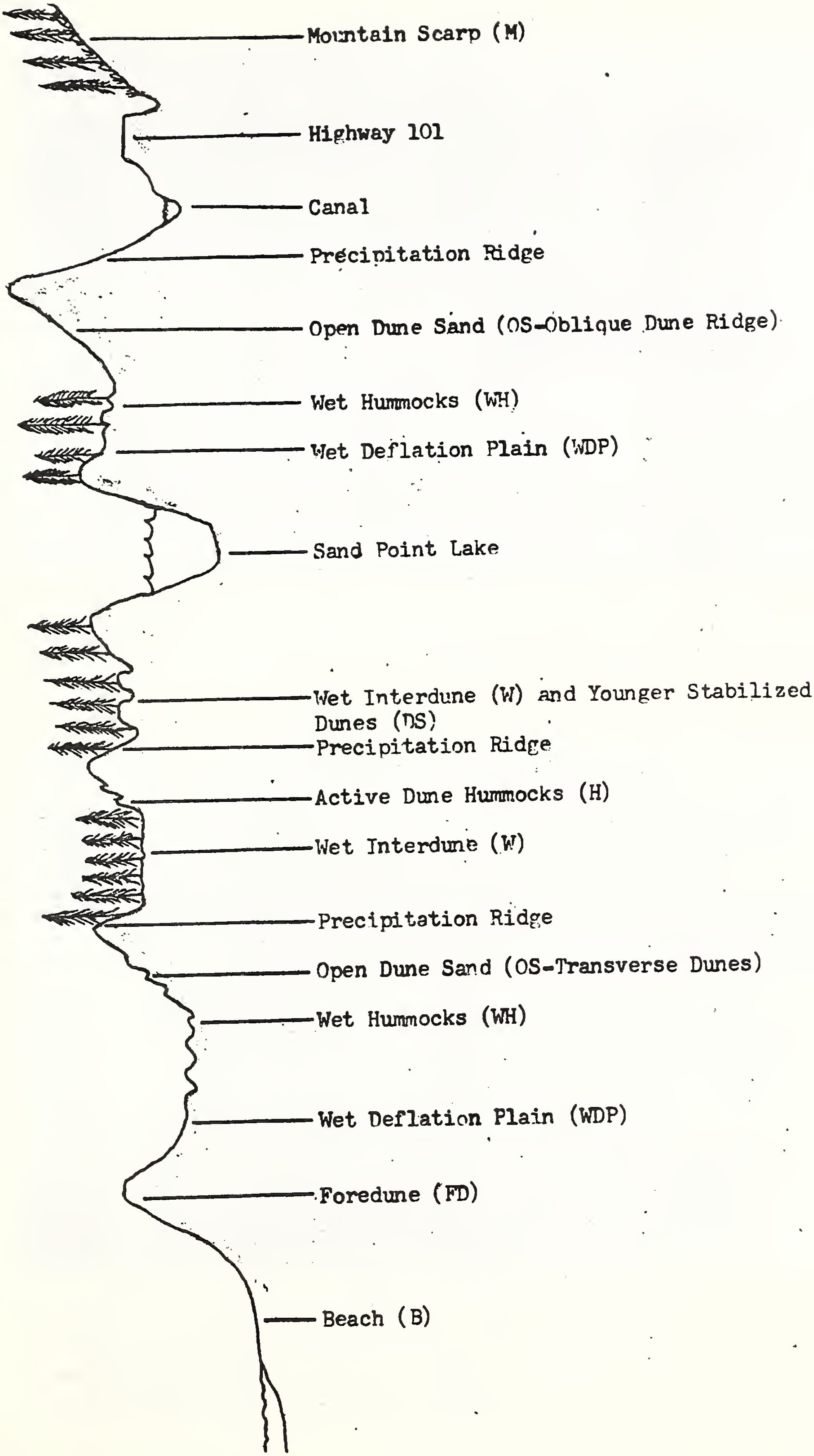


Figure 4 - Sand Point Lake Generalized Cross Section

Adapted from "Resource Inventory Report for Oregon Dunes National Recreation Area." Pacific Northwest Region, United States Forest Service, 1972.

Figure 5 - Dune encroachment into Cleawox Lake, Lane County. The leading edge of the active dune as shown in the photograph only lacks about 150 feet to bisect Cleawox Lake, and close the outlet of the upper lake.

Figure 6 - High active dune (OS) that is encroaching into the south side of the Siuslaw River near Florence, Lane County. The eastward movement of the precipitation ridge across the younger stabilized dune (DS) is also apparent.

Figure 7 - Precipitation ridge advancing into a wet interdune (W) area along Highway 101, at a location south of Carter Lake in Douglas County. The dead trees shown on the precipitation ridge were a part of a younger stabilized dune (DS) that was buried. The photograph was taken during winter (early March 1974), when wet interdune area ponds a large quantity of water.

Figure 8 - Precipitation ridge of active dune (OS) advancing across younger stabilized dune (DS) and encroaching onto North Road, north of Manzanita in Tillamook County.

compared. They are inviting to both pedestrian and vehicular travel but because of low relief, distances become deceptive. Two other significant management factors are that active transverse dunes are transient and; lower edges of wet transverse dunes often contain quicksand. However, active transverse dunes have a high natural appeal and should be managed for their scenic and recreation values.

Oblique Dunes (included in OS)

Oblique dunes have a broad sloping ridge and a slip face. Cooper coined the term because their crests are irregular and usually oriented obliquely to both northwest (summer) and southwest (winter) winds (see Figure 9) (11). In the NRA study area oblique dunes were described as attaining heights of 180 feet with five to 30 percent slopes on the windward side and 60 to 70 percent leeward slopes (36). The crest of a group of parallel oblique dunes may form a precipitation ridge with a steep slip face. Such a situation is shown along the east edge of the open dune sand in Figures 3, 4, 7 and 9.

This dynamic and spectacular dune form does not support a plant community. As in the case of transverse dunes, wildlife species only use the oblique dunes for traveling to and from adjacent areas. Oblique dunes invite use by pedestrians, equestrians, and vehicles. The steep slip faces of the oblique dunes are primary areas for climbing, sliding, and running, and are probably what the recreationist most anticipates and remembers.

Parabolas (included in OS)

Parabolic dunes result from a trough blowout (see Figure 10) of major size and require:

(1) a vegetated, stabilized surface which concentrates the wind at the point of weakness;

(2) considerable initial thickness of sand; and

(3) unidirectional wind source.

Figure 9 - Active oblique dune (OS) in Coos County that occurs east of the lower end of Tenmile Creek. Wet interdunes occur in the troughs between dune ridges.

Figure 10 - Active parabola (OS) in Douglas County that occur northwest of Tahkenitch Lake. Parabola is oriented southwest to northeast.

The NRA report (36) describes active parabolas as open dune sand associated with vegetated areas on three sides, usually grading into oblique dunes on the fourth side. Parabolas migrate inland parallel to an unidirectional wind force and can be seen oriented either parallel (southeast direction) to summer winds (see Sand Dunes Map, Douglas County, OS west of Tahkenitch Lake) or parallel (northeast direction) to winter winds (see Sand Dunes Map, Tillamook County, Sheet 3, OS east of Cape Kiwanda).

When an initial blowout occurs, exposed sand is enlarged laterally to a degree, but primarily longitudinally, and a landform is created similar in cross section to a parabolic curve (36). Slopes range from 0 to 40 percent with a vertical relief of 10 to 60 feet.

In terms of use characteristics, wildlife species may cross these areas when traveling to and from adjacent vegetation. They have an interesting appearance to recreationists, but the slip faces on the leeward slopes are dangerous areas for vehicles, due to partially buried trees and proximity to the tree line. In management of these areas it is important to understand that parabolas generally indicate that active dune movement is taking place.

Active Dune Hummocks (H)

Active dune hummocks are those hummocks which are actively growing by sand accumulation or decreasing by deflation (wind erosion). They generally occur above the water table, but wet areas are not uncommon. Active dune hummocks were extensively examined in the NRA study (36), and it was determined that pioneer grass species were becoming established in some areas, whereas others were being eroded. The water table is generally below the ground surface (Figure 11), but there are associated wet hummocks (Figure 12) which have a water table at or near the ground surface during the winter. Therefore, wind erosion on hummocks is generally confined to the summer and fall. Active dune hummocks and wet hummocks generally are found along the edges of wet deflation plains, particularly on the east side (see Figure 3). The NRA study (36) determined that vertical relief in wet hummocky areas varied from 10 to 30 feet, with horizontal distances varying from 20 to 30 feet at the base. Wet hummocks are not easily distinguishable from dry active dune hummocks during the summer. However, wet hummocks become distinct during winter because of standing water and frequent areas of quicksand.

Figure 11 - Active hummocks (H) along the beach west of Lily Lake, Lane County. Hummocks show undercutting, after a January 1973 storm.

Figure 12 - Wet hummocks in the foreground and active foredune, and active hummocks in the background, in the area southwest of Lily Lake in Lane County.

On the active dune hummocks, the dominant plant species are seashore lupine, European beachgrass, and seashore bluegrass, but beach knotweed, beach silvertop, gray beachpea, and coast morning glory also occur. A similar group of plant species occurs on the less active wet hummocks, and occasional dwarfed shrubs or trees also occur on the seasonally wet unit (36).

In terms of use characteristics, active dune hummocks have a high recreation appeal because of their visual contrast, vantage points, and temporary shelters from wind and sun. Both the active (dune) hummocks and the wet hummocks support a large variety of wildlife species; 34 species of birds have been identified in these areas (36). Active dune hummocks and wet hummocks represent good wildlife habitat that can be easily disturbed by man's activities. The plant community will not survive under heavy pedestrian and vehicular traffic. In addition, wet hummock areas are a hazard to pedestrian and vehicular use because of quicksand limitied visibility for cross-country vehicle use.

Motorcyclists seem to be particularly attracted to active dune hummocks and wet hummocky areas because of the isolated hills that can be circled. This type of activity appears to be the greatest contributor to destroying beachgrass and associated vegetation.

Active Foredunes (FDA)

Development of foredunes as part of the beaches and dune formation process has already been discussed. However, no clear distinction has been made between active foredunes (FDA), and wind conditionally stable foredunes (FD).

Active foredunes (FDA) can be described as a growing barrier ridge of sand immediately above the high tide line and paralleling the beach. They usually form as a new dune on a low beach ridge with a log debris base and receive such a substantial sand supply that the vegetation is predominantly a beachgrass community. As observed during this inventory, they generally have greater than 15 percent open sand patches along the crest of the active foredune during the summer, and more than 40 percent open sand patches during winter months (see Figure 13). Active foredunes are still growing in height. European beachgrass can tolerate burial by as much as three feet of sand annually and still maintain vegetation for sand lodgement which increases foredune height.[7]

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[7] Wilbur Ternyik - Personal communication. Soil Conservation Service Sand Dunes Workshop, Florence, Oregon, February 5, 1974.

Figure 13 - Active foredune (FDA) that occurs west of Siltcoos Lake in Lane County. The photograph shows a winter view looking south parallel to the beach.

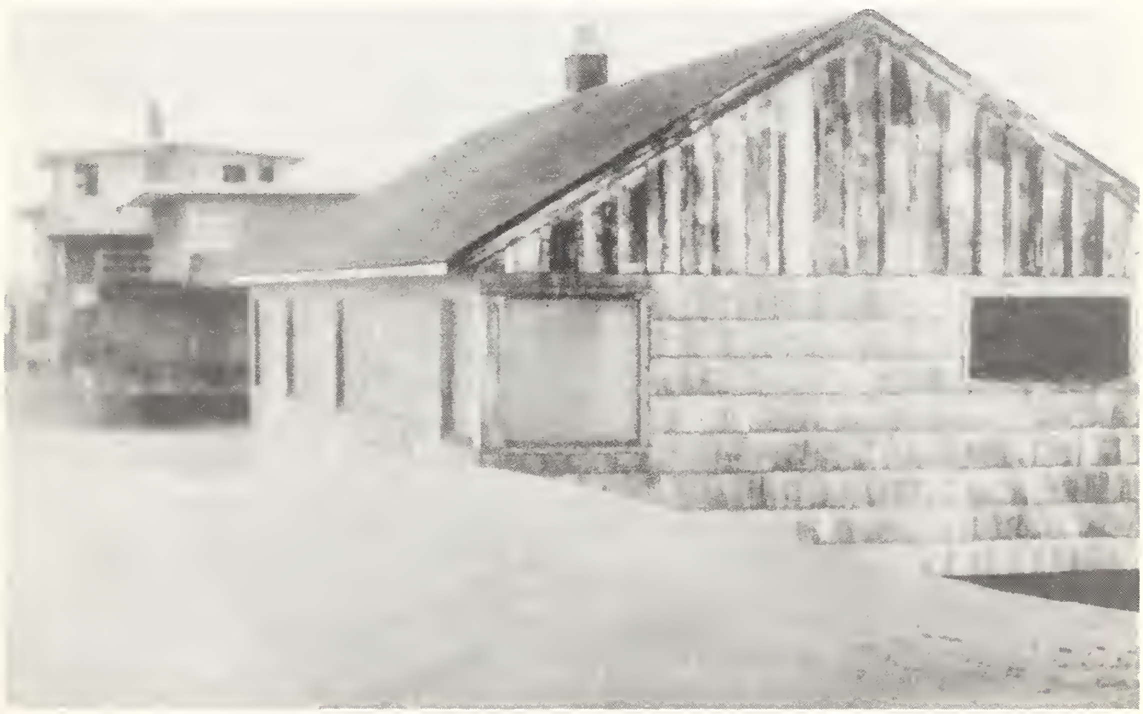

Figure 14 - Active foredune (FDA) encroaching on building in Seaside, Clatsop County.

There are 62 miles of active foredunes along the coast of Oregon. However, because of the scale used in mapping, many conditionally stable foredunes (FD) were included with active foredunes (FDA).

Active foredunes vary in height from about two to 25 feet on their leeward side. The width across the base of the foredune varies with wind, density of cover, and blowout conditions in any given areas; in general, the width varies from 10 to 200 feet. Active foredunes are partially covered by a vigorous European beachgrass community because of the natural fertility of sand blown off the beach. In addition, due to the mound building ability of European beachgrass, the hillocks formed are well above the water table.

The NRA study (36) determined that few species of wildlife use European beachgrass as habitat. However, snowy plover, considered rare in Oregon, nest in the driftwood adjacent or parallel to active or conditionally stable foredunes along beaches and sand spits (36). The Oregon Dunes National Recreation Areas contains approximately 27 percent of the snowy plover habitat in Oregon, so disturbance of the active foredunes or conditionally stable foredunes such as those that exist in the NRA, will affect a significant percent of the snowy plover in Oregon.

Recreationists sometimes find active foredunes to be a visual barrier. Development of European beachgrass hillocks and the sharp tips of the beachgrass discourage people from walking through the beachgrass. The result is that pedestrians travel in open sand patches, or along previously trampled beachgrass, until a trail develops. Open sand patches tend to be kept open in readily accessible areas as a result of foot traffic and sand sliding.

Occasionally motorcycles travel through active foredunes, but this is a dangerous activity because of the inability to see pedestrians among the valleys or troughs that occur throughout the tall beachgrass. In addition, vehicle traffic tends to compact the sand and significantly decrease beachgrass emergence. This results in a formation of troughs along the vehicle paths as the adjacent beachgrass areas grow in height and frequently to development of a blowout.

The trampling of the European beachgrass on active foredunes usually is not as significant as it appears. Beachgrass is constantly receiving new fertility from the blowing sand and continues to regenerate and survive. Active foredunes are tolerant of pedestrians. However, if an attempt is made to stabilize an active foredune that is beginning to stabilize naturally, then restriction of foot traffic will enhance establishment of beachgrass and consequently the development of a conditionally stable foredune.

A good perspective on the problem of development on active foredunes can be obtained by examining the 2.8 miles of ocean facing shoreline along the city of Seaside in Clatsop County. Fifty percent of the shoreline is associated with active foredunes or active open dune sand. Figure 14 shows active foredune encroachment in Seaside. Figures 15, 16, 17, and 18 also show the danger of constructing houses on active foredunes in Tillamook and Lincoln Counties. Figure 18 is particularly meaningful because it shows a small dune ridge on the east or landward side of the active foredune on the Alsea spit. This small dune was formed by the high east-southeast winds that passed through Alsea Bay in January 1973.

Active foredunes are shown on the sand dune maps of all the coastal counties. However, because of the small scale used in the inventory mapping, on-site investigation by a qualified sand specialist should be used to identify active foredunes in any given area. On-site investigation is also appropriate because of the wind erosion hazard, and the associated hazard of ocean undercutting.

RECENTLY STABILIZED DUNES

There are several dune forms classified as being recently stabilized from wind erosion. This group includes conditionally stable foredunes (FD), open dune sand conditionally stable (OSC), dune complex (DC), and younger stabilized dunes (DS).

Foredunes (FD)

These foredunes (FD) are active foredunes (FDA) that have become conditionally stable with regard to wind erosion (see Figure 19). They frequently occur as a higher barrier ridge of sand than exists for active foredunes with vertical relief along the leeward side varying from five to 30 feet; the horizontal base distance varies from 15 to 250 feet. The size and specific gravity of the sand particles, and the vegetation present, are important factors in the development of these conditionally stable foredunes. For example, once a foredune has become a ridge of substantial height, the size and specific gravity of the sand particles influence the ability of the wind to transport additional sand across the foredune. The result is that sand accumulates on the windward side, or the sand is

Figure 15 - Active foredune (FDA) encroachment around building in Manzanita, Tillamook County.

Figure 16 - Alsea River north spit in Lincoln County. The two houses in the middle foreground occur on an active foredune (FDA). A drained deflation plain (WDP) occurs landward of the active foredune (FDA).

Figure 17 - Active foredune (FDA) near the tip of Alsea River north spit in Lincoln County. The accumulation of blowing sand around a log debris base is apparent in this view looking east. The sand is about three feet deep around the base of the structure.

Figure 18 - Active foredune (FDA) along Alsea River north spit in Lincoln County. The view shown is to the northwest. A new sand ridge has formed on the east side of the active foredune as a result of east-southeast onshore winds. A paved access path crosses the partly breached active foredune and a sand ridge formed by east-southeast winds which occurs on this path.

swept parallel to the face of the foredune and along the beach. However, the same result can be obtained by seasonal or cyclic decreases in average wind velocities.

In this inventory, foredunes have been classified by age as: active foredunes (FDA), conditionally stable foredunes (FD), inland foredunes (IFD), and older foredunes (OFD). Once the ridge of an active foredune (FDA) reaches such size that salt spray and sand accumulation are decreased, additional plant species become established along the crest and on the leeward side of the active foredune. Indicator species for conditionally stable foredunes are coast strawberry, pearly everlasting, false dandelion, yarrow, seashore lupine, purple beachpea, bristly hawkbit, salal, Indian paintbrush, and tree lupine. These plants either do not occur or occur in only limited amounts on active foredunes.

There are an estimated 76 miles of conditionally stable foredunes on the Oregon coast. However, because of the small scale used in mapping, active foredunes are occasionally included with foredunes. Figures 2-H, 4, 19, 20, and 21 show foredunes in Coos, Lane, Lincoln, and Tillamook Counties.

If sand is deposited along a beach more rapidly than it is blown away, a beach will build oceanward and the vegetation will advance to the new storm tide line. Under these circumstances an active foredune will develop oceanward from a foredune which becomes conditionally stable. The foredune will support vegetation better suited to stable conditions and litter accumulated on the landward side of the foredune will begin to contribute significantly to organic matter in the surface soil horizon. Organic matter binds to the soil and enhances the soil's resistance to wind erosion. Increased organic matter will also result in a soil profile that can support a forage cover, stand of timber, or a speciality crop.

A sequence of foredunes has developed in Clatsop County as a result of an oceanward movement of the beach. All four types of foredunes occur in this area.

The NRA study (36) determined that the landward side of the foredune in the occasionally wet, somewhat hummocky area, where abundant shrubs occur, supported 54 species of wildlife, 37 of which were birds. The northern alligator lizard, striped skunk, savannah sparrow, and sparrow hawk were species found in the beachgrass habitat. In addition, the snowy plover frequently nests in the driftwood adjacent to this mapping unit.

Recreationists have the view of the beach obstructed if they stand landward from the foredune, but the foredunes also affords a vantage point if climbed. However, the discomfort of walking through beachgrass concentrates foot and illegal vehicle traffic

Figure 19 - Foredune (FD) along the south spit of the Siuslaw River, about 4 miles south of the mouth of the Siuslaw River. Winter view looking north, with some new accumulation area in left foreground and undercut area in the left background.

Figure 20 - Undercut foredune (FD) along Nedonna Beach in Tillamook County.

along trails. This increases trampling of adjacent beachgrass particularly along troughs in the foredune where slopes are more gradual. The beachgrass is not as tolerant in these areas because the foredune heights reduce the availability of new increments of sand and the nutrients it carries; the beachgrass may not recover from excessive trampling.

Once the beachgrass vegetation becomes thinned by trampling, sand is exposed and begins to blow. A blowout (see Figure 23) may form under these conditions and a section of a conditionally stable foredune can become an active foredune. Therefore, excessive concentrated trampling on foredunes should be controlled. This can be readily accomplished by proper signing and provision of curved access paths over the top of the foredune. In general, breaching of a foredune for access should be avoided. This type of opening tends to concentrate increased wind velocities in the opening, which enlarges the breach, and piles sand on landward facilities.

Fertilizing foredunes will help maintain the vigor of the beachgrass, and in turn, its ability to withstand trampling. However, annual fertilization can result in such a heavy ground cover that it creates a significant fire hazard. Therefore, if extensive fertilization of a foredune and adjacent areas is planned, consideration should be given to planting scotch broom or other shrubs as firebreaks.

There are many locations on the Oregon coast where homes exist on foredunes. Some of these homes have existed for 30 years or more without apparent wind erosion problems. However, even though some structures may exist on foredunes without serious wind erosion, these areas may be unstable because of ocean undercutting (see Figure 20). Undercutting of wind stable foredunes and active foredunes on Salishan Spit, (see Figures 21-22), Lincoln County, during the winter of 1972-73, and on Bayocean Spit, Tillamook County, during 1930-1952 (31), are prime examples of ocean undercutting.

Foredunes occur at low elevations adjacent to the beach, and can be readily undercut if the forces are available. Erosion can be caused by waves from a severe winter storm, of infrequent nature or by seismic sea waves.

A serious undercut danger to foredunes and active foredunes would accompany a combination of strong winds, high tides and a seismic sea wave. Such threats would be most acute during spring tide, when the earth, moon, and sun are aligned (41). At those times the lunar and solar tides reinforce each other. Under these conditions waves could readily go over or cut through foredunes and active foredunes.

Figure 21 - Modified foredune on Salishan Spit in Lincoln County. The framed building was undermined by the 1972 storm.

OREGON COASTAL CONSERVATION AND DEVELOPMENT COMMISSION PHOTO

Figure 22 - Modified foredune shown in Figure 21. This photograph taken on January 26, 1973 shows the remnants of the framed building.

OREGON COASTAL CONSERVATION AND DEVELOPMENT COMMISSION PHOTO

Figure 23 - A blowout in a foredune in Lily Lake area of Lane County. OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRY PHOTO

Figure 24 - New planting, mapped as conditionally stable (OSC), along Del Ray Road in Clatsop County. The road cut is appropriately signed to discourage disturbance.

Seismic sea waves or tsunamis are a hazard to near-shore development on foredunes or active foredunes, because Oregon lies within the circum-Pacific belt of earthquake activity. The causes and general behavior of tsunamis are understood (2, 26, and 41), but the specific response of these waves at a particular site is complicated to determine. Some of the factors influencing their behavior are direction of travel, width, configuration of the continental shelf, nature of the shoreline, estuary shape, and other less understood factors (41).

To calculate the force of a tsunami it is necessary to know the velocity and direction of flow, as well as the water level as a function of time (41). In addition, the nature and shape of the object are important. Therefore, it is difficult to generalize data from areas damaged by tsunamis and compare it to other areas. However, the magnitude of tsunami waves should be appreciated.

One estimate of water particle velocity in a tsunami wave was made at Seward, Alaska after the 1964 earthquake. Calculations showed that water velocity required to overturn a locomotive was 24.5 feet per second with an average pressure force of 700 pounds per square foot (41). Another estimate (2) of water velocity in the 1964 tsunami wave front at Crescent City was 11.2 feet per second over a depth of six feet. This Crescent City tsunami wave front velocity would be less than the actual wave velocity (41) and would represent more of a bay area condition than an open shore condition. However, Figure 212 in Technical Memorandum 25 (41) shows a beach shoreline area south of Crescent City with tsunami debris piled to about 25-35 feet above the beach. In the photograph (41, page 334), the debris appears to occur in the position of the foredune and may, in effect, be occupying the space or covering a pre-existing foredune.

As indicated, velocities of tsunami waves can only be compared to other areas in a general way. However, it should be understood that erosive velocities along streams, in sands of the type that occur in foredunes, occur above three feet per second. The same erosive velocities along streams for this type of sand that is well vegetated with Reed canarygrass, would be about seven feet per second for parallel flow.

Tsunami data available in Oregon (26) indicates the maximum wave height in estuaries varied from seven to 14 feet as a result of the 1964 tsunami; no data is available about its effects on the foredune. However, Oregon was fortunate during the March 28, 1964 tsunami because the initial direction of impetus of the seismic sea waves was away from the Oregon coast; the intervening continental shelf aided in refracting and dissipating the waves; and the generally high and rugged coastline of Oregon resulted in ultimate dissipation of the waves on unpopulated shorelines (26).

The size and growth of active foredunes or of conditionally stable foredunes is dependent on sand supply and its wetness, European beachgrass or other cover that provides lodgement, size and specific gravity of the sand particles, and wind velocity. Therefore, uses that affect or modify these controlling factors need to be managed. This, of course, presupposes that the resource present should be preserved; there is no uniform agreement at this point.

The USFS study (36), concluded that the foredunes now present throughout the length of the NRA, have become effective in slowing offshore winds. The result is almost total interception of the fresh sand supply coming off the beach, and in turn, effective cutoff of sand supply to the active open sand dune that lies to the east. Therefore, they recommended selective removal of the foredune to allow the open sand direct access to the beach sand supply (36).

Removal of the active foredune or conditionally stable foredune would probably result in obtaining the objective of preserving and maintaining open sand for a specific recreation area. However, if the same reasoning is applied to the remainder of the coast, substantial sand deposition damage will result to existing developments and public works, lakes, wildlife areas, agricultural lands, and forests. In other words, active or conditionally stable foredunes provide a protective wind barrier. Removal of the barrier will increase wind erosion and sand deposition in the landward area, such as the wet deflation plain. Therefore, removal of the foredune would result in destroying existing wildlife habitat in the wet deflation plain as well as that along the foredune.

<u>Inland Foredunes</u> (IFD)

On Sheet 1 of the Clatsop County Sand Dunes Map (see Map Appendix), many conditionally stable foredunes formed since 1935 are shown as inland foredunes (IFD). Only the present conditionally stable foredune along the beach is shown as FD. Inland foredunes are vegetated with native grasses and shore pine and sitka spruce. However, careful management of these areas is important because the inland foredunes could be easily reactivated if vegetation were removed by fire or overgrazing.

Open Dune Sand Conditionally Stable (OSC)

This mapping unit was used for active open dune sand areas that have been planted to European beachgrass and secondary plants in recent years. Occasionally this mapping unit was used to apply to active foredunes or to conditionally stable foredunes that have been flattened by earthmoving equipment. Some drained deflation plains have also been included. In all cases, any areas shown as open dune sand conditionally stable, is vulnerable to becoming active due to the fragile nature of the plantings. There are 4,920 acres of this unit mapped in the inventory.

Sand dune areas have been stabilized to reduce sand encroachment on buildings, lakes, rivers, and forests. Typical conditionally stable areas are shown in Figure 1 (west side of Cleawox Lake) and at location Db of Figure 2 (around the water tower).

Relatively few species of wildlife utilize the European beachgrass community as habitat; this portion of the conditionally stable dunes is probably only used by wildlife in traveling to and from adjacent areas. However, minimal wildlife habitat does exist in the scotch broom and assoicated secondary shrubs, as well as in the shore pine and associated trees which provide permanent wind stabilization.

Recreationists tend to avoid the area because of the sharp, pointed beachgrass. Occasionally, pedestrians, equestrians, or vehicular recreationists encroach on these stabilized areas resulting in increased wind erosion. Figure 24 shows recent stabilization of road cuts along Del Ray Road. These road cuts would be classified as being open dune sand conditionally stable with appropriate signs to discourage vegetal disturbance; Figure 25 shows vehicle damage along this road.

Within the Sand Lake high dune (Sheet 2, Tillamook County Sand Dune Map) there has been an attempt to protect the main paved road by forming a conditionally stable dune along the road. This dune, called an active interior dune (AID), is shown in Figure 26. Stabilization by this technique can be effective in road protection, but the dune shown in Figure 26 was formed too close to the road. As a result, sand building up on the dune is presently creating a substantial accumulation of sand on the road.

Other areas along roads in the Sand Lake high dune are classified as open dune sand conditionally stable because of natural plants and introduced beachgrass cover. Such an area is shown in Figure 27. Off-road recreational vehicle use has prevented stabilization of the area shown in the photograph.

Figure 25 - Disturbed conditionally stable area along Del Ray Road about one-half mile west of the view shown in Figure 24.

Figure 26 - Active Interior Dune (AID) formed by planting beachgrass along the west side of the paved road which crosses the Sand Lake high dune in Tillamook County. Blowing sand now collects on the dune (AID) and on the road.

Figure 27 - Disturbed conditionally stable (OSC) area on Sand Lake high dune in Tillamook County. This particular part of the area was stabilized to protect the adjacent road. Adjacent areas of open sand were set aside for dune buggy and motorcycle use.

Figure 28 - Sequence of iron bands in an active dune (OS) near Florence in Lane County. These bands affect vertical permeability and can occur in other dune types.

Some small open dune sand conditionally stable areas have been successfully used for housing. However, in these areas provisions must be made to restrict trampling of the grass which could result in a blowout and for fire control. Therefore, management practices such as planting, fertilization, fire control, road locations and pavement, proper building siting, access control, and signing must be used in these fragile areas.

Dune Complex (DC)

Included in this unit are open sand conditionally stable areas, active open dune sand areas, wet interdunes, and stabilized areas which occurred together in areas too small to be delineated separately at the inventory mapping scale. The use characteristics most applicable for these areas are those of the open dune sand conditionally stable, because this mapping unit is the most fragile unit included. There are 1,405 acres (see Table 2) mapped as dune complex.

YOUNGER STABILIZED DUNES (DS)

These are youthful, cross-bedded, wind-stable dune landforms that have weakly developed sandy soils with little or no development of cemented nodules, lenses, or Bir horizons. Vegetation on these dunes ranges from native grasses, European beachgrass, and shrubs such as scotch broom and tree lupine to woody species. The dominant tree is shore pine, but sitka spruce, western hemlock, Douglas fir, western red cedar, Oregon crabapple, and red alder also occur. There are 14,945 acres (see Table 2) of younger stabilized dunes mapped in the inventory.

The younger stabilized dunes mapping unit was separated from the older dunes stabilized unit by differences in soil profile characteristics and the predominence of shore pine and other woody species. Texture and cementation were the primary criteria used, with organic matter, depth, and distribution also considered. The cementation of the soil profile was examined and tested for its inherent stability to resist wind erosion without vegetative cover. The principal soils are the weakly developed Westport series (Figure 28a) and a soil mapping unit referred to as stabilized dune land (37).

28a. Younger stabilized dune (DS) showing weakly developed Westport soil series. The Westport soil series consists of deep, excessively drained fine sand and loamy fine sand, with little or no cementation or Bir horizon.

28b. Older stabilized dune (ODS) showing weakly cemented Bir horizon of Netarts soil series. Typically Netarts soils have black fine sandy loam A1 horizons; distinct, light colored loamy fine sand A2 horizons, and variegated fine sand Bir horizons with weakly cemented modules and lenses.

Soil characteristics and interpretations for the Westport soil which is typical of this mapping unit are given in the Soil Interpretations Appendix.

The younger stabilized dune mapping unit includes the stabilized dunes, and transition forests used in the NRA inventory (36). The NRA study established that these mapping units contained many species of birds, mammals, amphibians, and reptiles. Occasional snags serve as nesting areas for a variety of birds. In addition, this area is used as grazed woodland.

The dune stabilized mapping unit offers the greatest opportunity for the placement of man-made facilities. Established vegetation provides shelter from the wind and a location from which to venture out into the open sand. However, on-site investigation is needed because building sites may be limited by slope, depth of water table, and horizontal and vertical permeability if septic tanks are used.

The subsurface stratigraphy in younger stabilized dunes can significantly affect direction of subsurface flow. For example, Figure 28 shows a stratigraphic sequence of open sand and iron bands located west of Florence in Lane County (see Figure 2-Ac). These sloping iron bands control the direction of subsurface flow; they occur irregularly in open dune sand, open dune sand conditionally stable, younger stabilized dunes, and in older stabilized dunes.

The subsurface statigraphy of any given dune may also reveal buried soils of older dunes. For example, Figure 29 shows a blowout, where recent wind erosion has downcut through a Westport soil. It also downcut through the eroded remnant of a Netarts soil profile that occurs in the subsurface. The slope configuration of the eroded Netarts soil indicates that vertical percolation through the younger stabilized dune soil would be deflected laterally along the sloping remnant of the older soil if there were a continuous buried soil.

Some septic tank drain field failures have been reported in areas mapped as younger stabilized dunes. The reason for the failures is not known but buried soils, iron bands in the open sand, and high water tables are probable causes. One documented failure occurred northeast of Cleawox Lake in Lane County.

Surface or subsurface drainage that significantly reduces soil moisture in stable areas might result in the killing of low shrubs. Areas of decreased cover could ultimately become blowouts unless replanted to grasses or types of shrubs that could survive on drier sites. Excavation and vegetation removals in stabilized dune areas need to be well managed, to prevent exposure of open sand to wind erosion.

Figure 29 - Blowout in dune stable mapping unit (DS) with Westport soil in Tillamook County. Wind erosion has also exposed an eroded remnant of a Netarts soil profile (dark band of a truncated Bir horizon) whose topographic configuration outlines the previously buried older stabilized dune (ODS).

Figure 30 - Open sand area (OS) in Lincoln City, Lincoln County, that is exposed and blowing as a result of the removal of vegetal cover on an older stabilized dune (ODS).

OLDER STABILIZED DUNES (ODS)

There are 80,955 acres of older stabilized dunes (ODS) and associated older beach deposits (coastal terraces) along the Oregon coast. The dunes are wind stable landforms that have soils with weakly cemented nodules and lenses to strongly cemented nodules or strongly cemented Bir horizons. The dunes are cross-bedded sands, and the vegetation ranges from native grass to diverse forest.

The most characteristic soil mapped in this mapping unit is the strongly developed Netarts soil, soil characteristics and interpretations for the Netarts soil are given in the Soil Interpretations Appendix. Other soils that are common in this mapping unit are Bandon, Bullards, Blacklock, and Ferrelo.

Dominant forest species occurring on this mapping unit are western hemlock, Douglas-fir, sitka spruce, western red cedar, shore pine, alder, and willow. There is little difference between forest types growing on older stabilized dunes and those that occur on the adjacent coastal terrace or mountain front. However, the NRA study (36) concluded that a number of factors separate the transition forest of stabilized dunes, which is equivalent to the older stabilized dunes as used in this inventory, from the adjacent mountain front areas. Forest characteristics on the older stabilized dunes are open tree canopy, small trees, crowns formed and pruned by wind, and a dense shrub layer. In contrast, the mountain front area has larger trees, a denser canopy, and less shrub growth on the forest floor.

The predominant shrub species found on older stabilized dunes are rhododendron, salal, evergreen, huckleberry, trailing blackberry, salmonberry, and thimbleberry. If these areas have been recently clearcut, other forbs and grasses are present. The NRA study (36) indicates that hemlock, sitka spruce, and Douglas-fir are the most numerous trees growing in clearcuts, but patches of western red cedar and shore pine were found.

A greater number of wildlife species occur in older stabilized dunes than in any other mapping unit used in this inventory. The diversity of wildlife is a result of the open canopy, well developed shrub layer, and abundance of snags and trees of various ages. The NRA study's (36) transition forest was determined to be inhabitated by 145 species including 97 species of birds, 38 species of mammals, 7 species of amphibians, and 3 species of reptiles. Old growth timber is critical habitat for the bald eagle, osprey, red-tailed hawk, and great horned owl. While none of these species were found nesting in the old growth transition forest, these species do favor large trees or snags for nesting (36). Domestic animals also make

extensive grazing use of this unit, particularly in Coos and Curry Counties.

The older stabilized dunes offer about the same opportunities for man-made facilities as the younger stabilized dune areas. However, building sites are limited by slope, depth of water table, and horizontal and vertical permeability which limits subsurface flow. The oxidation and iron banding is more significant in the older stabilized dunes than in the younger stabilized dunes because of their greater age.

A survey of Lane County sewage systems and conditions[8] revealed a high incidence of septic tank failures in the older stabilized dune areas. This was particularly true in the Glenada and Dunes City surveys.[9] Surveys of the sewage systems and conditions conducted in Lincoln County[10] on the same mapping unit show an 80 percent failure in the D River survey; a 20-40 percent failure in the north Newport survey; a 55-64 percent failure in the Waldport survey; and a 47-88 percent failure in the Yachats survey.

Older stabilized dunes can sustain more surface disturbance than any other dune mapping units because of the soil profile. Typical Netarts, Bandon, and Bullards soils are wind stable even in vertical cuts, unless excavations exceed the depth of oxidized and cemented horizons.

In many areas, quarry and road cut excavations have penetrated the iron cemented zones to reach fresh open sand. The exposed open sand has formed small open dune sand areas. Such a situation in Lincoln City is shown in Figure 30.

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[8] Information obtained from Water Pollution Control Division, Department of Environmental Management, Lane County, September 1974.

[9] Ibid.

[10] Information obtained from a Lincoln County Health Department Report for 1968 and 1972 on Sewage Systems and Conditions in Lincoln County.

Older Foredune (OFD)

This dune is a wind stable former foredune that lies approximately parallel but away from the beach, and which has soils with weakly cemented nodules and lenses to strongly cemented Bir horizons. Older foredunes could be included in the older stabilized dune mapping unit, but they are separated because of the many identifiable older foredune landforms in Clatsop County.

Older foredunes typically have well developed Netarts soil profiles. Vegetation and use characteristics described for the older stabilized dunes are also applicable.

INTERDUNE FORMS

Many geomorphic features that occur among the dunes are classified as interdune forms in this report. Wet deflation plains, wet interdunes, lakes, flood plains, and surge plains are included in this group.

Wet Deflation Plains (WDP)

Those broad interdune areas which are wind scoured to the height of the summer water table are called wet deflation plains (WDP). This landform type usually occurs landward from mapping units FDA, FD, and IFD. Erosion of wet deflation plains generates a sand supply for dunes that lie landward. There are 15,285 acres mapped on the Oregon coast; typical occurrence is shown in Figure 3.

The NRA study (36) determined that the water table underlying the wet deflation plain fluctuates three to five feet between summer and winter seasons, and that wind erosion of wet deflation plains appeared to have eroded to the level of the water table in very dry years. Observations made during this study indicate that this general relationship applies to wet deflation plains throughout the coast.

Vegetation on wet deflation plains may vary from an association of grasses, sedges, and rushes (Figure 31) through a low shrub stage, (Figure 31) to a tall shrub thicket of willow, wax myrtle, salal,

Figure 31 - Winter view of a deflation plain in northern Douglas County showing transition from an association of grasses, sedges and rushes through low shrub stage.

Figure 32 - Road culverts under Siltcoos Road in Douglas County, that allow free drainage of the deflation plain.

shore pine, and sitka spruce, to a shore pine forest. The grass, sedge, and rush plant community as habitat, is used by 92 species including 78 birds, 10 mammals, three amphibians, and one reptile (36). The low scattered shrub plant community of the wet deflation plain provides habitat for 70 species of wildlife including 55 species of birds, 11 mammals, three amphibians, and one reptile. The tall shrub thicket area supports 29 birds, seven mammals, three amphibians, and one reptile. Most birds inventoried in this habitat were songbirds; black-tailed deer were abundant. Livestock use the drier portions of the wet deflation plain for grazing.

The grass, shrub, and rush vegetation of the wet deflation plain has an appealing atmosphere for viewing waterfowl, particularly the whistling swan which is dependent upon this habitat. The associated low scattered shrub areas of the wet deflation plain are also attractive to people interested in viewing wildlife, since these sites are drier. The tall shrub thicket also has some value for viewing wildlife, particularly birds, but the taller vegetation often obstructs much of the view.

Waterfowl habitat on the wet deflation plain can be greatly enhanced by planting Hannchen barley for feed. Barley planted in June will produce up to 40 bushels of grain per acre by fall.[11]

Proper management of wet deflation plains requires provisions for free drainage under roads that cross deflation plains. An example of adequate drainage is shown in Figure 32.

Occasionally, there have been attempts to utilize wet deflation plain areas for housing. The wet deflation plain is artificially drained as shown in Figure 33. This is unfortunate because drainage of the deflation plains removes some of the most desirable broad, flat, and wet, wildlife habitat along the Oregon coast. There were only 15,285 acres of wet deflation plain mapped; about two-thirds of the broadest wet deflation plains occur in the Oregon Dune National Recreation Area (see Table 2). Local drainage of the geomorphically unique wet deflation plain has a significant effect on the available wildlife habitat in the areas.

Housing on wet deflation plains that use subsurface sewage disposal will probably cause effluent contamination of groundwater and effluent discharge on the beach. Even though wet deflation plains have a large organic matter buildup, the mineral soil profile is highly permeable (i.e., six to 20 inches per hour) fine sand near the water table.

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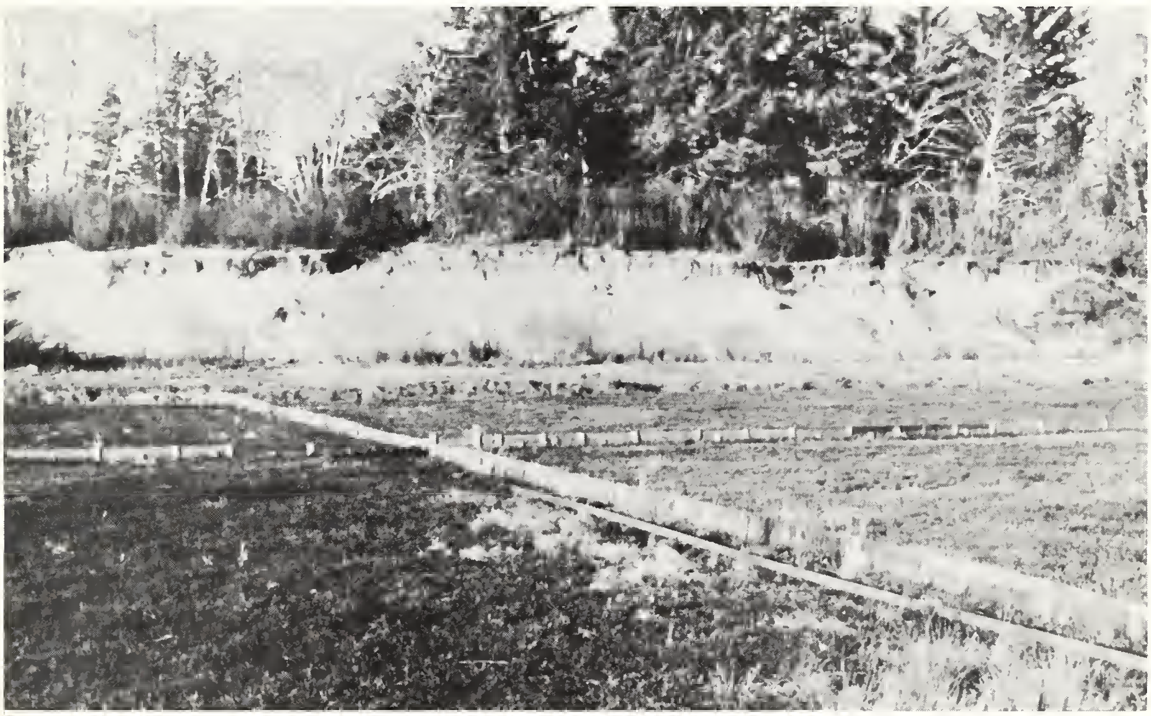
[11] Wilbur Ternyik, Sand Dunes Stabilization Specialist, Personal Communication, Soil Conservation Service, Sand Dunes Workshop, Florence, Oregon, February 5, 1974.

Figure 33 - Drained deflation plain (WDP) behind the foredune that occurs north of the Alsea River in Lincoln County. The area is to be sub-divided and developed.

Figure 34 - Wet interdune (W) area on the east side of North Florence that appears to be an old deflation plain.

34a. Wet interdune (W) between older foredunes in Clatsop County. This wet interdune is a narrow remnant of a former wet deflation plain (WDP) and could be classified as an older deflation plain (ODP).



34b. Wet interdune between older foredunes (note observe Netarts soil profile) in Clatsop County. The area shown as wet interdune is an older deflation plain (ODP) that is presently being cultivated.

Wet Interdunes (W)

These areas include a broad range of geomorphic landforms varying from wet open dune sand forms to wet areas in recent and older stabilized dunes. Wet interdune swales between active dune ridges are shown in Figures 4 and 9. There are 23,695 acres of wet interdunes shown on the inventory maps.

In general, broad areas that are both stable and wet were mapped as wet interdune and the stabilized area was shown as being secondary. This arrangement points out the major unit to be managed. Most wet interdunes are principally wildlife habitat areas. However, many areas mapped as wet interdunes are old deflation plains or re-exposed coastal terraces, such as shown in Figure 34.

The wet interdunes, if broad (Figure 34), are frequently developed. Such a situation occurs in north Florence, Lane County where a modified wet interdune area is extensively developed. Evaluation of subsurface disposal conditions in this area reveals that 75 percent of the sewage systems are failing.

Narrow wet interdunes between older foredunes are shown in Figures 34a and 34b in Clatsop County. These wet interdunes are mapped where former wet deflation plains existed. The wet interdune in Figure 34b is cultivated.

WET MOUNTAIN FRONT (WMF)

The wet mountain front (WMF) mapping unit is directly associated with the dunes because it represents wet areas that were entrapped by advancing dunes. There are 2,295 acres mapped at wet mountain front.

COASTAL TERRACE

The coastal terraces of the Oregon coast record the landward progress of erosion and deposition by the ocean. In other words, coastal terraces are former strandlines of the sea. No attempt was made in this study to map any specific coastal terraces, but coastal terraces were shown where they were overlain or modified by older stabilized dunes and associated interdune areas.

OTHER MAPPING UNITS

Floodplains and surge plains were mapped as interdunes. They reflect the geomorphic and climatic history of the area. Occasionally, a mapping unit is shown in brackets ( ) which indicates units of secondary importance that were included with the principal landform.

Along most of the coast there is a distinct scarp break (landscape break) from the dune or interdune mapping units to the adjacent highlands. This transition is shown as mapping units M for mountain front.

UNDERCUTTING AND DUNE ADVANCEMENT

Red boundary lines are used on the sand dunes map to represent active ocean or river undercutting, active dune advancement, or wind erosion.

Undercutting

Areas observed to be undercut during the field evaluation phase of this study are shown on the maps. The mapping unit indicates the general type of material being undercut. However, there are large differences in the resistance to erosion by the rock formations that make up the mountain front mapping unit. Mapping units used in the inventory vary somewhat in erosiveness because of slope and density of vegetative cover.

Maps in the publication by Schlicker, et al. (27, 28, and 29), and by the U.S. Army Corps of Engineers (34) also depict undercutting. The maps in the Schlicker publications are particularly useful since the differences in rock units are shown.

Rates of undercutting need to be established in specific areas to determine the amount of prior land loss and projections for the future. Schlicker (28) indicated for example that marine terraces in Lincoln County could be expected to retract from six inches to one foot per year, but could reach 10 feet per year in certain areas.

Figures 20, 21, and 22 show the effects of undercutting along a foredune area in Tillamook and Lincoln Counties.

A comparison of aerial photos taken over a period of years was made for 1.6 miles of foredune coastline immediately south of the south jetty at Newport in Lincoln County. The area between the vegetation line on the foredune and the west side of U.S. Highway 101 was used as the control section on two sets of aerial photographs taken on October 5, 1952 and May 24, 1972. The study revealed that about 9.3 acres of foredune was lost over the 1.6 miles during the 10-year period. Figure 35 shows a portion of South Beach State Park after severe undercutting associated with storms and high tides in January 1973.

Undercutting along the Siuslaw South Spit was evaluated in an area about one mile south of the jetty for the time period 1943-1972. The west vegetation line receded at an average rate of three feet per year. The foredune vegetation line appeared to recede in a northward direction, with an average rate of recession being 12 feet per year at about H on Figure 2 for the 30-year period.

Undercutting was also evaluated along the hummocky edge of the deflation plain shown as G on Figure 2. This area of the Siuslaw South Spit had an average bank retreat of 460 feet for the 29 years between 1943 and 1972. Figures 36 and 37 show the bank retreating at G on Figure 2 due to erosion between November 29, 1972 and March 13, 1973.

Undercutting of older stabilized dunes in Lincoln County is shown in the background of Figure 38.

Dune Advancement

Dune advancement around Cleawox Lake at Honeyman State Park, Lane County for periods from 1936 to 1972 are shown in Figure 1. In the area evaluated there were 22 acres of advancement or 4.4 acres per year for the years between 1936-41; 0.2 acres or 0.02 acres per year for years between 1941-1952; 5.7 acres or 0.63 acres per year for the years between 1952-1961; and 1.8 acres or 0.16 acres per year for the years between 1961-1972.

Figure 35 - Foot path across foredune in South Beach State Park, Lincoln County, undercut by storm of January 1973.

Figure 36 - Streambank undercut along Siuslaw River in Lane County. Photograph shows condition as of November 29, 1972.

Figure 37 - Streambank undercut along Siuslaw River in Lane County in the same view as shown in Figure 36. Photograph shows condition as of March 13, 1973.

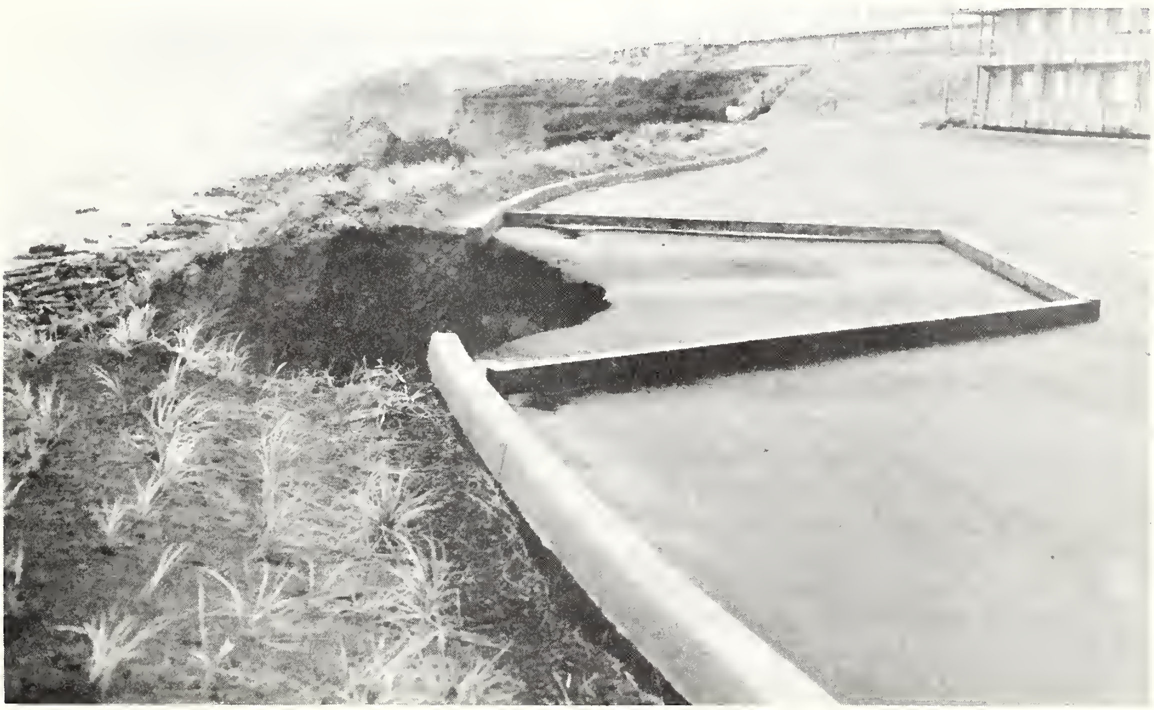


Figure 38 - Older stabilized dune (ODS) in Newport, Lincoln County, after undercutting, slumping, and runoff erosion associated with January 1973 storm.

Another dune advancement evaluation is shown in Figure 2. The high active open dune sand in Florence, Lane County at location A was evaluated for the 20 years between 1952 and 1972 and was found to have an overall eastward advancement rate of four to five feet per year. The northeast corner (Aa) has an average movement rate of 12 feet per year with local knowledge indicating that it has moved as much as 40 feet in one year. The southeast corner (Ab) has an average rate of nine feet per year with most of that occurring in recent years because of the wind gap opening provided by the airport. The rate of movement along the dune shown at A on Figure 2 has been projected for the next 50 years to show expected dune locations. A previous dune advancement evaluation of the open dune sand at A, Figure 2, was made by Cooper (11) for the time period 1946-1951. The overall rate of movement was determined to be 3.5 feet per year.

The high open dune sand at C on Figure 2 east of Florence was determined in the 1945-1951 study to have an average movement of 2.4 feet per year. The open dune sand at D on Figure 2 was evaluated for movement into Clear Lake (Dd) and found to have an average rate of movement of six feet per year. The same high dune was found to be moving south (Da) at 6.5 feet per year and northeast (Dd) at 15 feet per year.

SAND DUNES MAPS

According to Cooper (11), the Oregon coastal dunes can be divided into four regions based on natural characteristics of shoreline and dune formations. The first region, the Clatsop Plains, is 18 miles in length and strongly influenced by the Columbia River. The shoreline has advanced seaward creating a chronological, almost continuous series of foredune ridges, which are parallel to the beach (11). The Clatsop Plains extend south from the Columbia River, to Tillamook Head. This region is found on Sheets 1 and 2 of the Clatsop County Sand Dune Maps (see Map Appendix).

The second region which extends 125 miles from Tillamook Head to Heceta Head, is characterized by a retreating shoreline with isolated active open dune sand areas separated by headlands and rocky shoreline. Active dunes usually occur adjacent to bay and river mouths and are almost all parabolic dunes associated with blowouts in varying stages of degradation. This area includes Sheet 3 of Clatsop County, Tillamook County, Lincoln County, and the northern third of Lane County (see Map Appendix).

The dunes of the third region, called the Coos Bay dune sheet (11), rest upon a large coastal terrace which is 54 miles long. The active dunes extend as far as 2½ miles inland. From Heceta Head to Cape Arago the continuity of the dune sheet is broken only by the Siuslaw and Umpqua rivers and small streams as they flow into the ocean. This has resulted in the development of massive, complex, and heterogeneous dune formations some of which reach heights of 165 feet. This region is covered by Sheets 2 and 3 of Lane County, Douglas County and Sheets 1 and 2, and the northern part of Sheet 3 of Coos County (see Map Appendix).

In the fourth region which lies between Cape Arago and the California border, the only significant active dunes occur in a 12 mile coastal strip bisected by the Coquille River. The younger stabilized dunes are not massive or of great height, but extend inland as much as a mile. Older stabilized dunes occur associated with coastal terraces and extend up to about 3.5 miles inland. South of Cape Blanco, the shoreline is steep and rocky; therefore, most of the dunes occur adjacent to the mouths of creeks and rivers.

Previously, it was mentioned that prior to maximum submergence the shoreline stretched beyond what would later be the rocky headlands (11). As the sea advanced, a series of coastal terraces was formed and the shoreline was eroded irregularly because of variation in erodibility. Arkosic sand from the Klamath Mountains, was distributed throughout most of the coast. This sand supply, along with that from the streams entering the coast, provided the extensive sand supply necessary for formation of the high dunes (ODS, DS, and OS) which were associated with the period of sea advance.

With the lowering of sea level, the shoreline of the Oregon coast was further eroded and became more irregular. Littoral drift was contained between the major headland barriers. In the north these included the sectors between Tillamook Head and Cape Falcon; Cape Falcon and Cape Meares, which encompass the Nehalem River as well as the Tillamook Basin mouth; Cape Meares and Cape Lookout, which encompass the Netarts Bay area; and Cape Lookout and Cascade Head, which include the Sand Lake area and the Nestucca River area. These headland conditions described occur in the northern half of Cooper's (11) Region 2.

On the central coast, southern half of Region 2 (11), the barrier headland condition occurs between: Cascade Head, and Cape Foulweather, which encompasses the Siletz River; Cape Foulweather and Yaquina Head; Yaquina Head and Heceta Head which include the Yaquina River and the Alsea River.

The south central coast essentially consists of the Coos Bay dune sheet, Region 3 of Cooper, 11; the barrier headlands that contain littoral drift are Heceta Head at the north and Cape Arago on the south. These two headlands encompass many streams, but the major sediment contributors are the Siuslaw, Umpqua, and Coos Rivers. The sediments deposited by these rivers so greatly exceed those removed by drift, that modern active dune areas (OS) are extensive.

On the south coast, in the northern half of Region 4 of Cooper (11) the barrier headlands containing littoral drift occur between Cape Arago on the north and Cape Blanco on the south, these include the Coquille River and several smaller streams. This area contains abundant active dunes (OS) that are directly associated with the smaller streams.

Also on the south coast barrier headlands containing littoral drift occur between Cape Blanco and Port Orford to encompass the Elk River; Port Orford and Cape Sebastian includes Euchre Creek and the Rogue River; Cape Sebastian and Cape Ferrelo include the Pistol River; and Cape Ferrelo to Point Saint George includes the Chetco, Winchuck and Smith Rivers.

It is likely that all the major headland barriers along the Oregon coast have become more significant since maximum submergence. Therefore, the contribution of sand supply from the Klamath Mountains to present littoral drift volumes becomes less significant as increased headland development confines the littoral drift to local areas. The ocean has acted as a holding area for the arkosic sand from the Klamath Mountains and was particularly important in providing sand during the advancing sea for formation of the high dunes. However, with the lowering of sea level, the headlands eroded during the sea advance, tending to segment the coast and obstruct the littoral drift associated with the coastwide California and Davidson Currents. Therefore, further redistribution of arkosic sand from the Klamath Mountains by longshore currents is affected. This tendency would increase the importance of local areas between headlands as sand quarries for drift to form modern beaches and spits. These local quarry areas would work in combination with the local river sand supply areas.

The overall significance of assigning greater importance to local sand supply quarries and to river sources is that both of these sources are presently being changed. Bulkheading is cutting off the sand supply of many local shoreline sand quarry areas, reservoirs are storing some of the river sediment or reducing peak flows that flush sediment from estuaries, and jetties are changing the scour at the mouths of the rivers, as well as obstructing local littoral drift.

In the past, winter storms have efficiently eroded the coast, particularly the foredunes and spits, and caused the movement of sediment northward along the coast. However, much of the resulting sediment that moves as littoral drift will be confined within the headland barriers or restricted by jetties. During the summer there is a tendency for wave action associated with the southward California Current to rebuild the beaches with sediment provided by streams[12] and to provide a beach supply for rebuilding the foredunes by wind erosion the following winter. If a section of the coast tends to remain undercut throughout most of the year, then the winter erosion effect is exceeding the summer replenishment, and the coastline is temporarily unstable. This is essentially the condition mapped as undercutting on the sand dune maps. However, this condition is transitory, so areas that were considered to be undercut during the inventory mapping period may now be healed by new sand increments. In addition, other areas, particularly foredunes, have been undercut since mapping was completed.

[12] During the summer the streams of the Oregon coast, with the exception of the Columbia River, transport their lowest sediment loads.

Each of the counties mapped during the inventory will be briefly described in terms of the mapping units. In addition, particular dune problems will be described as well as littoral drift effects that pertain to beach and spit accretion or erosion.

CLATSOP COUNTY

On the Clatsop Plains (11), a series of parallel dune ridges with intervening troughs extend for 15 miles from the Columbia River southward to Tillamook Head. (See Clatsop Sand Dunes Map). This series of ridges extends approximately 1½ miles inland and consists of several ridges of older foredunes with well developed soil profiles (see Figure 34b), which are vegetated by spruce-hemlock forests. These older foredunes are separated by wet interdune areas which represent old deflation plains (see Figures 34a & 34b). The older foredunes are extensively used as pasture; some interdune wet areas (old deflation plains) are used for specialty crops like cranberries (see Figures 34b).

A sand dune project was established in the Clatsop Plains in 1935 by the Soil Conservation Service. In this program 3,000 acres of shifting sand were progressively stabilized by forming a series of foredunes. These recently formed foredunes are shown on the Clatsop County Sand Dune Map as FD & IFD.

The foredune and inland foredune west of the Necanicum River in Seaside are underlain by gravelly ridges. The source of the gravel may be partly from the Necanicum River and partly from littoral drift of basaltic rock and associated Miocene sedimentary rock that occur in adjacent Tillamook Head. Figure 39 shows the gravel beach ridge that occurs in south Seaside, where not overlain by beach sand or foredunes. As shown in Figure 39, the gravel beach ridge is overlain by recent tidal debris, and occurs in the foredune position. However, a sufficient sand supply is not present, and erosion is too active for a sandy beach and associated foredune to develop. The area south of Seaside is in contrast to most of the Clatsop County, where a sandy beached shoreline exists.

Sheet 1 of the Sand Dune Map for Clatsop County indicates that active undercutting is taking place along northern Clatsop County. Some small eroded segments occur in the reach north of Slusher Lake, but about 3 miles of continuous undercutting occurs one mile south of the Peter Iredale, Fort Stevens State Park. Erosion has become progressively worse along this reach since the time of inventory mapping,

with the foredune along part of reach being completely cut through. The immediate cause for this temporary unstable condition is the imbalance between winter removal and summer replenishment.

Examination of the historical causes for changes in this reach of the coast require examination of the changes that have taken place at the mouth of the Columbia River. Historically, the Columbia River has built a bar at its mouth. Prior to 1885, a 20-foot ship channel was maintained across this bar by dredging. In 1885, construction began on the south jetty. By 1935, the south jetty was built to a length of 7 miles, and the north jetty extended at least 3 miles out in the ocean. The direct result of construction of the jetties was that the Columbia River scoured its channel to a depth of 47 feet by 1937. The sediment scoured from this channel distributed north and south of the river mouth, with the result that new sand increments on the beach far exceeded the sand removed by winter storms. This resulted in the prograding shoreline and in the sand supply for the blowing dunes. Additional increments of sand that exceeded winter removal were common until about 1969. After that time, there appeared to be a reversal in the process, with erosion during the winter exceeding new sand increments. The reasons for the change are a complex set of interactions that involve the sand supply on the Columbia River system and the rate of sediment scour that occurs between the jetties.

Recent changes in these factors would need considerable evaluation before conclusions could be drawn. However, it is obvious that the beach along the northern Clatsop Plains is undergoing change, and that winter erosion is exceeding summer replacement.

In recent years the sediment deposited in the Columbia River estuary has not been annually flushed by high spring runoff of the Columbia River. Therefore it is expedient that studies be made on the Columbia River system to determine the expected future contributions of this system to the beach building process.

Clatsop County has a generalized shoreline length of about 31 miles. As of the time of this inventory about 16.5 miles or 53 percent was being undercut by the ocean.

TILLAMOOK COUNTY

This county has a generalized shoreline which is 53 miles in length, and which consists of sand beaches interspersed with rocky

headlands and nonbeach areas. About 18.5 miles or 35 percent of the Tillamook County shoreline, was actively being undercut as of the time of this inventory.

Tillamook County lies entirely within Region 2 described by Cooper (11). The dunes (see Tillamook County Sand Dune Map in Map Appendix) are usually associated with the many rivers and bays which are, from north to south: Nehalem Bay, Tillamook Bay, Netarts Bay, and Nestucca Bay. Other important dune areas occur along the sequence of lakes near Rockaway and Sand Lake. Most of the sand dunes (see Table 2) in Tillamook County are younger stabilized dunes (2,745 acres) and older stabilized dunes (1,700 acres). The 6,170 acres of active open dune sand generally occur in long narrow parabola strips that have a total length of encroachment of 14.8 miles. There are about 730 acres of active foredunes.

There has been substantial activity in stabilizing high active dunes; 1,275 acres are presently classified as open dune sand conditionally stable. The foredunes in Tillamook County tend to be active with 19 miles mapped as active foredune and 6.9 miles mapped as conditionally stable foredunes. There are about 1,025 acres of wet interdunes and 450 acres of wet deflation plain. Tillamook County has a larger area (1,100 acres) mapped as wet mountain front than occurs in any other coastal county.

Recent studies by Klingman (17) indicate that there is an extensive accumulation of sand on the south side of the south jetty of the Nehalem River. In addition, there is a net littoral drift to the north (17). However, littoral drift over the last 6,000 years was to the south as evidenced by the southward trend of Nehalem Spit. Neahkahnie Mountain and Cape Falcon are the major headlands to the north of Nehalem Spit, and Cape Meares is the major headland to the south of Nehalem Bay. Cape Falcon is the local quarry source in the north for sand needed to form Nehalem Spit and this local source works in conjunction with contributions from the rivers. A photograph of the Cape Falcon quarry source area is found on page 134 of Schlicker et al (27).

In recent years Cape Meares, which occurs south of Tillamook Bay, may have had only sufficient Miocene sandstone quarry area (27) along with river sand supply to provide sand supply for northward drift in the Davidson Current for Tillamook Spit, but not for that part of the coast north of Tillamook Bay. North of Tillamook Bay a strip of coastal terrace has survived the erosion associated with coastal submergence in the last few thousand years. The preserved coastal strip from Barview to Nedonna Beach indicates that the reach had not been used extensively in the past few thousand years as a continuous quarry source for northward drift, and therefore, formation of a south spit on Nehalem Bay. However, in recent years this

coastal strip has been actively eroded (see Tillamook County Sand Dune Map, Sheet 1). Therefore, the coastal strip between Barview and Nedonna Beach may be the local quarry area for the recent accumulation of sand behind the south jetty of the Nehalem and associated with the recent northward littoral drift described by Klingman (17). There must be a large sand supply along this reach of the shoreline since the foredune present is an active foredune, but one which is undercut (see Figure 20 and Tillamook County Sand Dune Map). Photographs of undercut foredunes and active foredunes along this coastal reach are found on pages 114 and 115 of Schlicker et al (27).

The recent net littoral drift is to the north near Tillamook Bay (17) so it is likely that there will be increased sand accumulation behind the new south jetty. Terich and Komar (31) indicated that the beach immediately south of the jetty accreted approximately 400 feet seaward from November 1971 to February 1973. The new jetty construction has been underway since April 1969. However, there is recent erosion along the midsection of the spit which could result in future problems. Observation of the Tillamook Sand Dunes Map, Sheet 2, indicates that southeast trending parabolas (see OS adjacent DS on Tillamook Spit, Tillamook County Sand Dune Map, Sheet 2) formed during the last 6,000 years on Tillamook Spit near its midsection. Recurrence of northwest winds in a magnitude that formed these parabolas, would cause associated waves that would be effective in eroding the midsection of the present spit. In addition, the southeast trending parabola on Tillamook Spit indicates it was probably attached to the land area at about Barview, in order to have a sand supply to form the parabola. This would indicate the need for a bay outlet near the south end of the spit, about where the Bayocean breaching of the spit occurred in November 1952. However, since the older stabilized dune and coastal terrace area north of Barview has not eroded as a sand quarry for the north spit, the change to form north outlet must have occurred near the time period of maximum submergence.

Netarts Bay is a re-entrant in the coastline that receives no drainage other than from intermittent streams. A northward trending spit encompasses most of the Bay, and littoral drift is predominantly northward in winter and southward in summer (23). The net littoral drift is probably northward since an active foredune occurs at the northern tip of the spit which indicates a recent increment of sand supply on the beach. Because Netarts Spit is encompassed by Cape Meares on the north and Cape Lookout on the south, the littoral drift along the coast north of Cape Meares may not provide much sand for the Netarts Spit and associated dunes. Therefore, if local areas are the present source of supply for recent features such as foredunes and active foredunes, then the sand must be derived from erosion of the coastal terrace and from younger stabilized dunes and older stabilized dunes. Some of the sand supply contribution is derived from

landslides of the sandy coastal terrace, such as shown by Schlicker et al, (page 120, 27). Periodic undercutting of the foredune occurs along Netarts Spit so a continued local sand supply is desirable to maintain a balance between aggradation and degradation along the beach.

Northward trending parabolas which occur north (see DS on Sheet 2, Tillamook County Sand Dunes Map) of Netarts Bay, indicate that localized high southwest winds have occurred in the geologic past. Recurrence of high southwest winds might cause erosion problems along the Netarts Spit, particularly at its northern end, where on-coming waves and the Davidson Current would not be deflected by Cape Lookout. Observation of Netarts Spit on the Sand Dunes Map shows that there are small open dune sand parabolas with a southeast trend, near the tip of the spit. These areas, along with the adjacent younger stabilized dune, lack a source area for sand supply. If Netarts Spit were attached to the headlands on the north, at a location about one mile south of Cape Meares, then there would be a sand supply for the remnants of the dunes on the spit. In addition, the headland area on the north has a southward curvature that could have entrapped northward moving littoral drift, similar to what has occurred at Cape Kiwanda. Therefore,a substantial sand supply would have been available to form the northeast trending parabolas, and later develop a southeast trending spit that was subsequently breached at its north end.

Nestucca Spit is a long southward trending spit that is almost cut through at its upward end by a meander of the Nestucca River. Littoral drift is south in the winter and north during the summer (17). Understanding the trend of the spit and the associated dunes such as the parabolas, requires understanding the geomorphic history. According to Cooper (11) a prominent headland occurred at the north end of the spit during the Pleistocene. Haystack Rock is a remnant of this basaltic headland that was flanked on its eastern side by weaker and more erodible sandstones and siltstones. In the latest major advance of the sea, Haystack Rock acted as a bastion of resistance by protecting the more erodible rocks to the northeast in what is now called Cape Kiwanda. During this period the shore retreated on both sides of Haystack Rock, but more rapidly on the south side of the Rock because of exposure to the severe winter (southwest) storms (11). This resulted in the development of a concavity northeast of Haystack Rock and a favorable location for the catchment of littoral drift moving northward. The sand entrapped in this concavity was available as sand supply for the several northeast trending parabolas (see OS and OSC, Sheet 3, Tillamook County Sand Dune Map) as well as for southward longshore transport.

LINCOLN COUNTY

This county has a generalized shoreline length of 54 miles, and like Tillamook County is characterized by sandy beaches interspersed with rocky headlands and inlets. About 42 miles or 78 percent of Lincoln County was actively being undercut during the time this inventory was made.

Lincoln County lies entirely within Region 2 described by Cooper (11). The modern dunes (FDA, FD, OS, OSC) occur associated with river mouths; older stabilized dunes (ODS) occur on coastal terraces throughout most of the county (see Lincoln County Sand Dunes Map in Map Appendix). There are 11,220 acres mapped as older stabilized dunes, which have modified coastal terraces, and 1,320 acres mapped as open dune sand conditionally stable, as opposed to only 115 acres of open dune sand.

Most of the land mapped as open dune sand conditionally stable occurs north of the Alsea River and east of Alsea Spit. Two large subdivisions, Bayshore and Sand Piper, occur in this area and beachgrass stabilization of the open sand dunes was done to protect them from blowing sand. Most foredunes in Lincoln County are associated with spits at the mouths of the major rivers. In the inventory, 12.1 miles of foredunes were mapped and 2.6 miles of active foredunes.

There were 755 acres mapped as wet interdunes in Lincoln County and 51 acres of wet deflation plain. The wet interdune areas are probably not large enough to be desirable wildlife habitat areas. A large block of former wet deflation plain has been drained (see Figure 33).

The local sand quarry source areas along the beaches are sandstones of the Nestucca Formation, sand derived from old beaches and dunes that underlie older stabilized dunes, and older stabilized dunes. Local beach areas in the northern part of the county, such as along Roads End State Wayside, are deficient in sand, so a gravelly beach occurs. Locally the adjacent coastal terrace that is overlain by older stabilized dunes has been bulkheaded or seawalled, but the effect bulkheading has on sand supply is unknown. Littoral drift in the northern portion of the county varies with the season, but in general is considered to be moving north (17).

A major spit occurring in northern Lincoln County is the northward trending Siletz Spit. As shown on the Lincoln County Sand Dunes Map, the northern part of the spit is overlain by an active foredune and the remainder is overlain by severely undercut foredunes. The undercut foredune on Salishan Spit is shown in Figures 21 and 22. Photographs showing the foredune in 1972 before severe undercutting,

where the west side of the foredune was east of the house, are photo 63, page 116 of Schlicker et al. (28) and later in December 1972 (28), January 1973 (28), and February 1973 (28). Over 100 feet of the foredune was eroded during the 1972-1973 winter storm period.

The central and southern coasts in Lincoln County consist mostly of coastal terraces overlain by older stabilized dunes. However, south of Yaquina Bay there are several reaches where foredunes occur. One reach previously described is the undercut foredune area along South Beach State Park. Localized foredunes occur south of this area to about Alsea Spit where a continuous foredune and adjacent active foredune occurs. The littoral drift in this area has a net littoral drift to the south (17). On the southern tip of Alsea Spit the active foredune indicates that new sand is being provided. This is consistent with an expected southward trend for littoral drift.

As previously indicated, a significant problem exists in Lincoln County in subsurface drain field waste disposal. The associated younger stabilized dunes have a slightly less severe problem, but most younger stabilized dunes were included with the older stabilized dunes in this inventory.

The other apparent problem in Lincoln County is that 41.5 of the 53.8 miles of ocean-facing shoreline were being undercut at the time of the inventory. Some remaining beach area not shown as being undercut, is bulkheaded. It is not known how long the sand supply from the local rivers and quarry areas can maintain a sandy beach. However, the bulkheading is cutting off some local sand supply. In addition, the jetties and headlands, both in Lincoln County and to the south, are cutting off sand for northward longshore transport that may be needed in the future to nourish the sand beaches of Lincoln County.

LANE COUNTY

This county has a generalized shoreline length of 29 miles. The northern portions consist of sandy beaches interspersed with rocky headlands. The southern portion has continuous sandy beaches, interrupted only by the Siuslaw River, and small stream outlets. About 23 miles or 93 percent of the shoreline was undercut by the ocean, at the time of the inventory.

Lane County lies in the northern portion of Region 3 (Coos Bay Dune Sheet) of Cooper (11). A major dune area occurs north and south

of the Siuslaw River, which is a major contributor of sediment to local littoral drift.

This part of the coast has 4,315 acres (see Table 2) of active open dune sand. These dunes have 29 miles of migrating leading edge.

Dune stabilization programs have been active; 1,320 acres of open sand conditionally stable were mapped. There are large stabilized areas with 5,305 acres mapped as older stabilized dunes and 2,670 acres mapped as younger stabilized dunes. A foredune occurs along most of Lane County with 11.5 miles of foredune mapped. A large wet deflation plain lies landward of the foredune, particularly south of the Siuslaw River. Overall, there are about 1,995 acres of wet deflation plain in Lane County, which is some of the best potential waterfowl habitat on the Oregon coast. Wet interdune areas also are abundant in Lane County with 5,485 acres mapped.

Examples of land use on dune forms in Lane County were given in the discussion of land uses in the NRA. Several example areas in Lane County were also discussed in the Dune Advancement section.

Schlicker (29) discussed the occurrence of ground water in Lane County dunes. He points out the possible adverse effect that lowering the water table in the wet interdune areas might have on lake water levels in Munsel and Collard Lakes. Collard Lake is particularly vulnerable since it is already being filled by dune advancement.

DOUGLAS COUNTY

This county has a generalized shoreline length of 17 miles, consisting of a continuous beach broken only by the Umpqua River, and small streams. About 9 miles or 53 percent of the shoreline was undercut when inventoried.

This county lies in Region 3 of Cooper (11). Open dune sand areas cover 4,035 acres (see Table 2) and these areas have a total of 17 miles of migrating leading edge. Only 95 acres were mapped as open dune sand conditionally stable; there is 1,710 acres of younger stabilized dunes; and 1,760 acres of older stabilized dunes. Twelve miles of foredunes and 4 miles of active foredunes were mapped.

Wet deflation plain areas cover 2,135 acres. Since this all occurs within the NRA, the valuable waterfowl habitat area can be maintained and improved.

The Douglas County dunes lie almost entirely within the NRA. The NRA report (36) fully discusses land use in this area, so no additional discussion will be given. The dunes in Douglas County are also described in the publication by Lund (20).

COOS COUNTY

This county has a generalized shoreline length of 49 miles, which is about 70 percent beach zone and 30 percent coastal terrace or rocky headlands. About 18 miles or 37 percent of the Coos County shoreline was undercut at the time of the inventory.

Coos County lies in both Regions 3 and 4 described by Cooper (11). The county is similar to Douglas County in that recent dune activity is very apparent; 7,295 acres (see Table 2) were mapped as open dune sand. These areas have a total of 40 miles of migrating leading dune edge. Only 315 acres were mapped as open dune sand conditionally stable, but younger stabilized dunes cover 4,475 acres. Coos County has a history of sand dune stabilization beginning in 1910. A large portion of what was mapped as DS has been stabilized in the past sixty years.

There is probably more preserved evidence of recent geologic history in Coos County than in any other area along the Oregon coast. There are several coastal terraces (14) that depict former strandlines of the ocean; older stabilized dunes occur on several terrace levels. No attempt was made to separate older sandy beaches of the coastal terraces (14) from older stabilized dunes. The soil development is similar on both types of landforms, and they are both underlain or associated with sand that has the potential for wind erosion if the vegetation is disturbed. There were 40,465 acres mapped as older stabilized dunes and associated older coastal terrace beach areas. Coos County has the largest area of this mapping unit on the Oregon coast.

A foredune or active foredune occurs essentially throughout the dune areas of Coos County, with 22 miles of foredune and 7.5 miles of active foredune.

Coos County contains the largest area of broad flat wet deflation plains with 5,820 acres inventoried. Much of the wet deflation plains in Coos County occur in the NRA and is managed for its wildlife potential.

The beach sand dune resources in Coos County are extensively described by Cooper (11), Griggs (14), Lund (20), Robinson (25), Twenhofel (32,33), U.S. Army Corps of Engineers (35), and the Oregon Dunes National Recreation Area study (36). Therefore, no additional discussion will be given.

The importance of the major rivers for sand supply to this portion of the coast was discussed in the geology section of this report. Coos County does have some undercut areas, but a comparison of the beach area west of Horsefall Lake indicated that the vegetation line of the foredune was moving oceanward at an average rate of 7 feet per year for the last 31 years.

CURRY COUNTY

This county has a generalized shoreline length of 82 miles. North of Cape Blanco the shoreline is dominated by low cliffed older stabilized dunes and coastal terraces along narrow sandy beaches. Cliffs and small embayments characterize the shoreline south of Cape Blanco, with the narrow beaches being composed of coarse sands and gravels. About one-half of the shoreline is beach zone, and 31 miles or 38 percent is undercut by the ocean.

Curry County occupies the longest reach of the Oregon coast but has the smallest area of modern dune activity. Only 610 acres are mapped as open dune sand; a stabilization program is indicated by the 1,390 acres mapped as open dune sand conditionally stable. There is some modern history of dune activity as evidenced by 1,775 acres of younger stabilized dunes but most of the dunes are remnants of earlier dune activity. In the inventory, 20,485 acres were identified as older stabilized dunes. They occur on multiple coastal terraces (14) and are associated with the older beach areas.

Foredunes and active foredunes are associated with spits at the mouths of the rivers. Nineteen miles of active foredunes and six miles of foredunes were mapped in the inventory. The spits and associated foredunes and active foredunes of small rivers, such as the Pistol and Elk Rivers, provide good evidence of the history of spit and foredune formation under conditions where jetties are absent. The Pistol River is a particularly good example of a river undergoing changes in estuary configuration and outlet.

The changing outlet of the Pistol River is discussed and displayed by Clifton et al. (10), for various time periods. These time periods

are displayed in Figures 38a, 38b, 38c, 38d, and 38e.

Clifton et al. shows a photograph of the Pistol River, taken during the February 1972 flood, with an outlet that is located about 100 feet north of the present outlet (see Figures 38f and 38g). Therefore, from the photographs, it appears that the Pistol River outlet moved north about 450 feet between February 1972 and July 6, 1972. By July 19, 1972 the outlet had moved 200 feet south and by August 25, 1972 the outlet was completely closed. The photograph taken April 4, 1973 (Figure 38f) showed the outlet had reopened and moved south about 400 feet.

Clifton also observed a farmstead located about 5 feet above water level in the left center of the photograph in Figure 38g[13]. This must have been prior to the development of the active foredune. Since the active foredune shown in Figure 38g has a northeast-southwest trend, it must have had a sand supply to the north. This would be possible if the main outlet of the Pistol River were several hundred feet to the north. Therefore, sometime after the farmstead was located at the mouth of the Pistol River, roughly about 1920, a northward trending spit developed that provided sand supply for the development of the active foredune shown in Figure 38g. Cooper (11) indicated that portions of this dune were present in 1940, with his reference to a dune advance that was threatening to overwhelm the farm. The spit changed its outlet after 1940 and developed a south outlet by 1953 that was due west of the bridge over U.S. Highway 101 (37).

The whole sequence of photographs referred to (Figures 38a, 38b, 38c, 38d, 38e, 38f, and 38g) show changes after 1953, and, therefore, the unstable nature of this natural spit.

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[13] H. E. Clifton. U.S. Geologic Survey, Menlo Park, California. Personal Communication. November 1974.

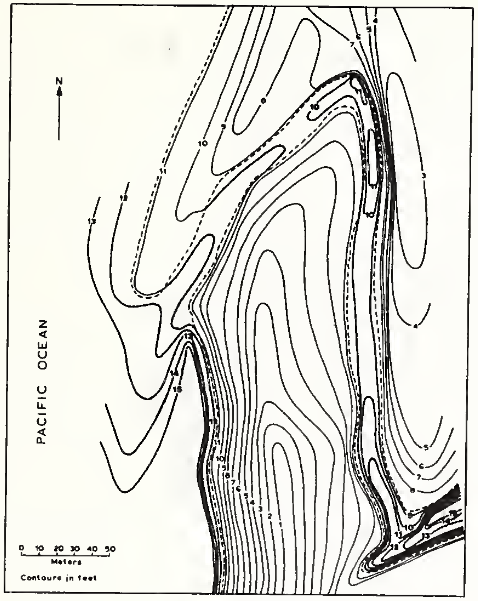

Figure 38a - Topographic map of the Pistol River mouth, July 6, 1972. Main estuarine basin lies to the east. Note position of previous channel directed toward the southwest and now partly marked by a westerly appendage of the estuary. Water level in the estuary at low tide.

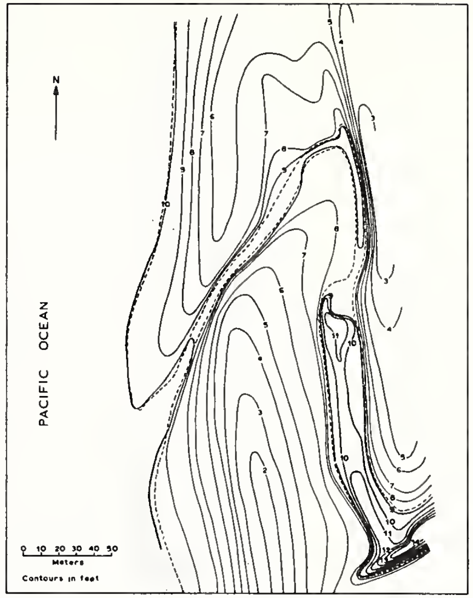

Figure 38b - Topographic map of the Pistol River mouth, July 19, 1972. Note the bend where the stream has migrated to the south since July 6 (Fig. 38a). Water level in estuary at low tide.

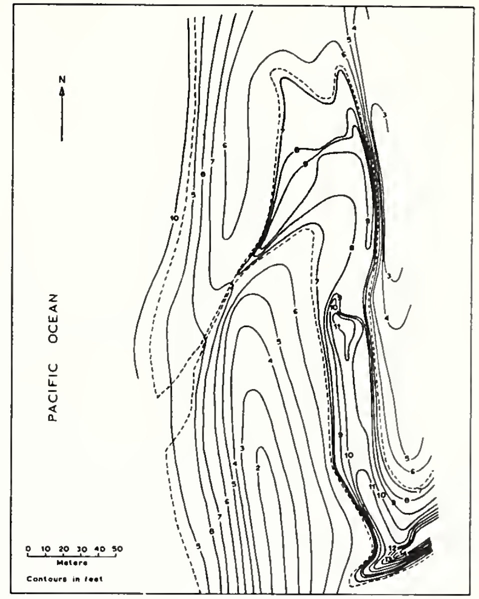

Figure 38c - Topographic map of the Pistol River mouth on July 20, 1972. Note that low tide in the estuary has risen considerably from previous day (Fig. 38b).

These figures adapted from "Depositional Structures and Processes in the Mouths of Small Coastal Streams, Southwest Oregon," H. Clifton, R. Phillips, & R. Hunter. Coastal Geomorphology 1973.

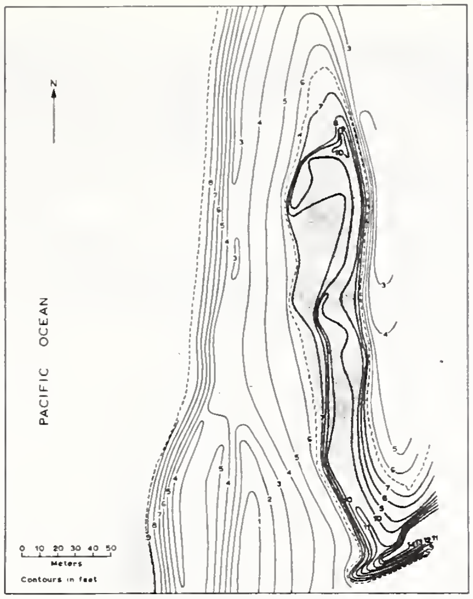

Figure 38d - Topographic map of the Pistol River mouth on August 25, 1972. Note the amount of lateral filling by berm overwash since July 20 (Fig. 38c).

Figure 38e - Pistol River mouth on August 25, 1972. Note figures at far end of stream for scale. Note also berm overwash pouring across the beach into the river.

These figures adapted from "Depositional Structures and Processes in the Mouths of Small Coastal Streams, Southwest Oregon," H. Clifton, R. Phillips and R. Hunter. Coastal Geomorphology 1973.

38f. Pistol River in Curry County showing spit configuration and outlet as of April 4, 1973. View is toward northwest.

38g. Pistol River, Curry County, looking west at undercut active foredune, and site of former farm buildings. March 19, 1974.

Figure 39 - Gravel beach ridge in Seaside, Clatsop County, that is overlain by float debris brought in by storm and associated high tide of December 1973.

Figure 40 - Sand fences used (in 1937) in building foredunes on Clatsop Plains, Clatsop County. It is necessary to use two parallel lines of fences 30 feet apart to obtain a stable foredune configuration. These dunes are now covered with shorepine and were mapped as inland foredunes (IFD).

SAND DUNE STABILIZATION

Probably the most comprehensive report about sand dune stabilization in Oregon is entitled "Controlling Coastal Sand Dunes in the Pacific Northwest", USDA Circular NO. 660 McLaughlin and Brown (21). Later publications (7 & 8) have discussed and modified the concepts and procedures presented, but the general procedures developed for the Clatsop Plains in Oregon still apply to foredunes. The high active dunes along the Oregon coast present additional problems not evaluated in the McLaughlin & Brown study but relatively little published research is available.

Since USDA Circular 660 is not generally available, methods of sand dune stabilization presented in that report and other related reports (4,5,7,8 & 21) will be presented here[14]. No attempt will be made to present details of plant succession, desired spacings, and fertilization. This type of information is available in other publications (7,8,21 & 40), and from knowledgeable individuals in the sand dune stabilization field.

METHODS OF CONTROL

Vegetation

Sand dunes may be stabilized by selective placement of vegetation or by mechanical means. For example, initial stabilization of blowing sand using several grasses, particularly European beachgrass is the firt step toward permanent stabilization. Grasses such as

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[14]Most of the published information concerning sand dune stabilization in Oregon, was developed for special areas such as the Clatsop Plains, and may not be directly applicable in other specific areas without modification. This is particularly true for the high active open dune sand (OS) areas.

European beachgrass and American beachgrass, thrive on the fertility associated with new sand increments, but the beachgrass will not form a permanent cover because it dies out when the sand is stilled. Therefore, permanent stabilization requires planting of perennial species after initial control has been accomplished.

Brown states that seedings with perennial grasses and legumes can be made into one year old plantings of beachgrass (7). This can be done if the beachgrass stands are vigorous and have stilled the sand. Field trials conducted by Brown (7) have also shown that legumes alone will not give permanent dune control, but grasses grown in combination with legumes provide permanent cover. The most satisfactory mixtures (7) contained hairy vetch, common ryegrass, purple beachpea, Clatsop red fescue, and tall fescue.

Brown and Hafenrichter (8) discuss the use of woody plants in dune stabilization, but point out that a permanent cover of woody plants on coastal dunes is never established directly on eroding sites. As indicated, shrubs are used as an intermediate stabilization step since they provide protection to growing trees against strongly desiccating winds and improve the fertility of the soil which benefits tree survival and growth.

The study by Brown and Hafenrichter (8) indicated that shrubs for intermediate stabilization must establish quickly, grow rapidly, withstand strong desiccating wind, and be tolerant to shade. In addition, leguminous shrubs are desired since nitrogen they provide assists in permanent tree establishment. Their studies (8) tested 75 species of native, naturalized, and exotic shrubs and found only 3 species suitable for intermediate stabilization. One species in particular, scotch broom, has all the desirable qualities, and could also be used alone as a good break. In addition, it produces an abundant crop of seeds which is used as food by birds.

Eighty woody species have been tested for use in sand dune stabilization (8). They are divided into those that give semipermanent stabilization such as shore pine, red alder, and hooker willow, and those that give permanent stabilization such as Sitka spruce, western red cedar, Oregon crab apple, and Douglas-fir. Shore pine is particularly well suited for semipermanent stabilization since it is easy to establish in intermediate plantings of shrubs, the growth rate averages two feet per year, and it quickly becomes wind formed (8). In addition, shore pine is an ideal medium for the natural establishment of the climax species which overtops the scotch broom and shades it out. Climax woody species are usually not planted because they volunteer readily in intermediate tree and shrub plantings.

Protection is essential to the success of most tree and shrub plantings used for stabilization. Fire, rodents, and man are the main hazards. Fire break-lanes in tree plantations using fire resistant species such as scotch broom or Clatsop red fescue are essential. Other provisions for fire prevention and control must also be made. Rodents such as mice, mountain beaver, and rabbit can damage young plantings and they must be controlled. Access should be controlled to prevent digging or trampling of plants, trail development, and fires in stabilized areas.

Other Methods

Brush Matting

Brush matting is sometimes used to stop sand blowing (21) and serves as a temporary stabilizer by acting as a mulch. The brush is laid flat on the surface of the ground, with a second row placed to overlap the first in a shingle fashion. On steep banks, brush may be staked down and secured by wire.

The value of brush matting is limited to temporary stabilization since the brush soon loses its leaves and becomes ineffective. Brush matting is used on blowouts on steep slopes, and appears to be successful only if used with seedings of beachgrass or shrubs. In practice, it has been difficult to obtain uniform stands of vegetation in this manner and local areas are subject to wind scour as the brush mat deteriorates (21). This practice should be avoided if possible because of its unsightly appearance.

Oil

Oil is used as a sand stabilizer on excavated cuts and trails. Such a situation, is shown in Coos County in Figure 41. Figure 42 illustrates damage to an oiled road cut by a vehicle. Generally, oil is inadequate for stabilization due to its unsightly appearance and should be avoided.

Wire Net

Wire net is used in stabilizing road cuts. Use of wire in Coos County is shown in Figures 43 and 44. As seen in Figure 43, the wire net with associated vegetation has effectively reduced wind scour. Figure 44 shows an adjacent area where the wire has become broken and twisted, and the remaining wire is being buried by sand deposition. This practice should be used sparingly, and only with associated plantings.

Figure 41 - Oil used to stabilize open sand (OS) road cuts, excavated in younger stabilized dunes (DS) along the road to North Spit of Coos River in Coos County.

Figure 42 - Vehicle tracks in oil stabilized road cut shown in Figure 41, that expose open sand to continued blowing.

Figure 43 - Wire net with two inch mesh used in stabilization of open sand (OS) road cuts, excavated in younger stabilized dunes (DS). This road cut occurs along North Banks Road in Coos County.

Figure 44 - Wire net broken and raveled along North Banks Road in Coos County, in a view about 50 feet south of that view shown in Figure 43.

Rock, Gravel, Clay, and Refuse Material

Crushed rock and gravel are locally used to cover open sand areas and to reduce wind scour. However, the source area for the sand may still be exposed and additional sand movement may bury the rock and gravel. Clayey and silty soils are also placed on top of blowing sand areas to provide temporary cover or mixed with the sand to develop a non-scouring material. These materials are also buried if the source of sand is not controlled. Refuse, such as street sweepings, has been successful in stabilizing limited areas of blowing sand (21). However, such material is only available around large cities and is not pleasing to the eye.

All types of pavement are used to cover open sand, but sand movement from adjacent areas can bury the pavement (see Figures 18 and 45). In some cases pavement or spread materials such as crushed rock, clay or refuse, may cause increased erosion, because their surface allows a smooth sweep for the wind and encourages sand accumulation in adjacent areas[15].

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[15] Wilbur Ternyik, Sand Dunes Stabilization Specialist, Personal Communication, January 1975.

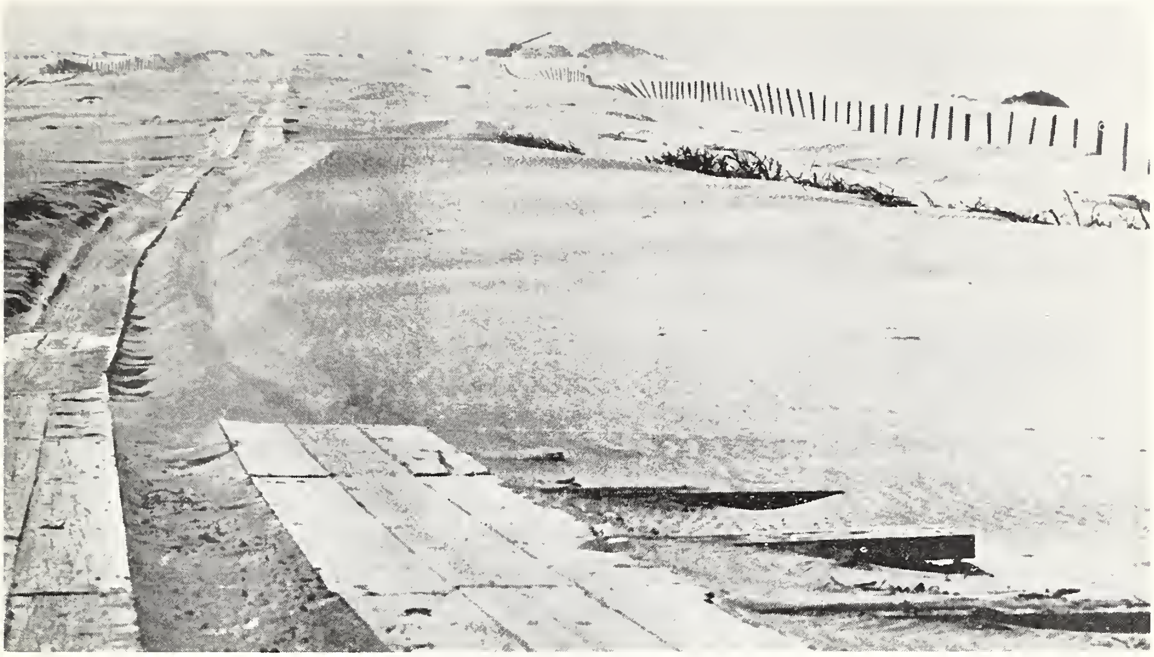

Figure 45 - Drifting sand in August 1935 is shown crossing wood plank road to historic 1906 Peter Iredale Shipwreck, in Fort Stevens State Park, Clatsop County. The shipwreck is shown at the sloping pole to the right of the road and sand fence.

Figure 46 - August 1936 view of wood plank road to Peter Iredale wreck, shown in Figure 45. The first year's growth of European beachgrass (Ammophila arenarca) is apparent.

MANAGEMENT

EXISTING BEACHES AND DUNES MANAGEMENT

Private Lands

A portion of the Clatsop Plains in Clatsop County is the only area on the Oregon coast where a comprehensive sand dune management program exists on private lands. The regulations were brought about by local residents who were worried because dunes were moving inland and damaging farm lands; the military reservation at Fort Stevens, the Oregon National Guard Camp at Camp Rilea; and resort properties. The jetty at the mouth of the Columbia and the main coastal highway were threatened. In 1935, the Soil Conservation Service at the request of local people, and in cooperation with the Oregon Agricultural Experiment Station and the Extension Service, established a work area for stabilizing these shifting sands.

An analysis of the causes of these dunes showed that three factors were primarily responsible for this large area of active sand. These are destruction of the natural cover by overgrazing, fire, and unwise recreational use. The other major cause was jetty construction at the mouth of the Columbia River. A wide sand plain formed immediately adjacent to the jetty as eddy currents redistributed the sand from the river and ocean.

Factors affecting a permanent solution were climate, soil, and land use. Winds were a severe hazard; mild temperatures and high rainfall were advantageous.

Solution of the problem required reconstruction of permanent vegetation, essential physical features, and provision for continuing careful management to insure maintenance of permanent vegetation and stable topography.

Possibilities for land use appeared to be pasture, agricultural speciality crops, and recreation. The first two were confined entirely to areas on the leeward side of the advancing sand. Recreational activities were confined to areas under public supervision, such as Fort Stevens State Park.

Active work on stabilization of moving sand in the Clatsop Plains was begun in November 1935 with assistance of the Civilian Conservation Corps. In March 1936 a nursery unit of the Soil Conservation Service was established for production of beach and dune grasses, collection of seed, production of shrubs and trees, and testing of plants and cultural methods.

On the Clatsop Plains dune area, permanent control of shifting sands was attained through the following progressive steps:

1. Establishing a barrier dune (foredune) (see Figure 40). This dune was necessary because of the wide plain built up by construction of the jetty; it provided protection from storm tides that sometimes swept back across the dune nearly one-half mile.

2. Initial sand-stilling by beach and dune grasses. This stage is essential before more permanent vegetation can be established.

3. Permanent stabilization by herbaceous or wood vegetation. This stage usually follows one or two years of beachgrass establishment. It is an essential step and must be properly timed for good results.

The Soil Conservation Service-CCC work had completed most of the initial control work on the Clatsop Plain dunes by 1941, but the permanent control plantings and maintenance work was essential. In the spring of 1941 the landowners on the dune area organized the Warrenton Dune Soil Conservation District under state law. This district (now in the consolidated Clatsop Soil and Water Conservation District) has been administering this work since that time with technical assistance from the Soil Conservation Service and other agencies.

A comparison over a period of time of unstabilized and stabilized dune areas in the Clatsop Plains is shown in Figures 45, 46, 47, 48, 49 and 50.

Cooperators with the Warrenton Dune Soil Conservation District wanted to insure permanent control of the shifting sands. In April 1948, this District established land use ordinances to enforce proper land use for the area. These regulations appear below.

Figure 47 - August 1937 view of wood plank road to Peter Iredale wreck shown in Figure 45. Established European beachgrass and Scotch-broom (Cytisus scoparius) is shown in the foreground. Wet areas along plank road are apparent in the center background. The new formed foredune is shown in the background in front of the Peter Iredale.

Figure 48 - September 1961 view of road to Peter Iredale shown in Figure 45 (26-year time span). Paved road has replaced the wood plank road. Semi-permanent stabilization by shore pine and Scotch-broom is apparent in the foreground. A 35-foot foredune hides the Peter Iredale shipwreck.

Figure 49 - Drifting sand in 1937 view of the present site of Fort Stevens State Park, Clatsop County. The dunes are shown encroaching on to trees that surround the west side of Coffenbury Lake.

Figure 50 - July 1955 view of Figure 49 (18-year time span) showing established European beachgrass, Scotch-broom, and shore pine, planted to protect Coffenbury Lake.

Warrenton Soil and Water Conservation District Regulations

Ordinances prescribing land use regulations for the care, treatment, and operation of certain lands designated as Zones 1 and 2 within the Warrenton Dune Soil Conservation District.[16]

WHEREAS, the lands within the Warrenton Dune Soil Conservation District are basic assets of the district and their preservation is necessary to protect and promote the health, prosperity, and welfare of the people in the district; and some of the lands are extremely susceptible to erosion by wind that damages not only the land from which the soil is blown but also the lands and improvements of neighbors; and erosion of such lands can be prevented by the maintenance of a continuous vegetative cover; and, the removal or destruction of even a portion of such cover by any act or use of the lands may result in the initiation of erosion processes that spread to other lands, causing economic loss and a hazard to the use and occupancy of the lands of the district by man or his animals, and (here omitted from this copy of the ordinance is the legal description of Zones 1 and 2. These legal descriptions are available on request, and the attached map gives the general location of district and Zones 1 and 2).

NOW THEREFORE be it ordained by the landowners within the Warrenton Dune Soil Conservation District, and within the area known as Zone 1, that:

Section 1. Erosion will be controlled and the soil stabilized by vegetative and/or mechanical means on all lands of this area. After stabilization, continuous maintenance will be provided.

Section 2. No livestock may be grazed in the area.

Section 3. Vehicular and recurring pedestrian and equestrian traffic will be restricted to hard surfaced (plank, gravel bound with clay, asphalt, or other material of like character) roads or trails.

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[16] This material was prepared by the Clatsop County Extension Office from original regulations on file in the minute book of the Warrenton Dune Soil Conservation District. 4/1/67.

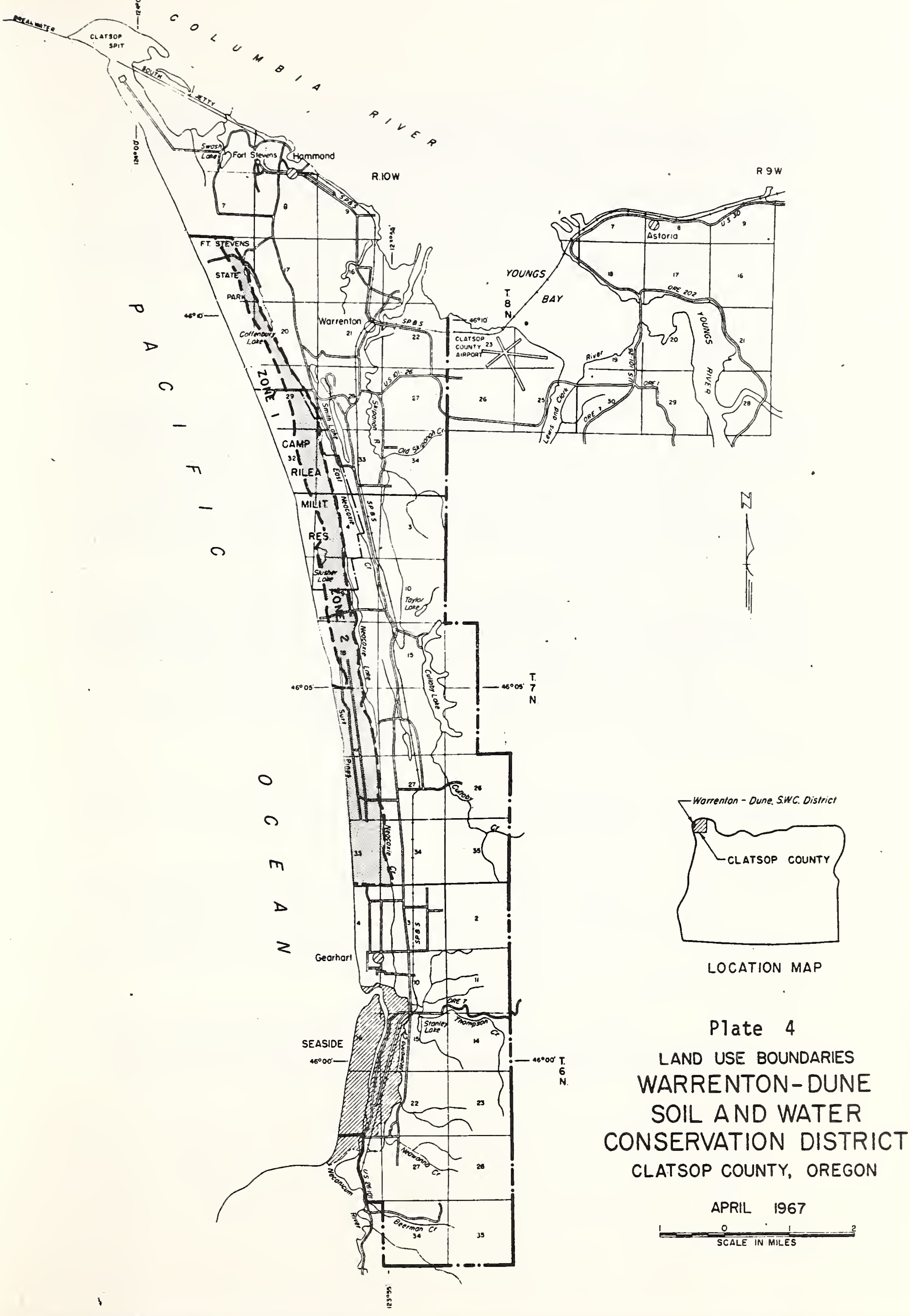

Plate 4

LAND USE BOUNDARIES

WARRENTON-DUNE SOIL AND WATER CONSERVATION DISTRICT

CLATSOP COUNTY, OREGON

APRIL 1967

Section 4. No roads or trails may be built by other than the County, State, or Federal Government without a permit from the Warrenton Dune Soil Conservation District Board of Supervisors.

Section 5. No building may be constructed in the area.

Section 6. No other acts or land uses that result in destruction or serious deterioration of the ground cover will be permitted except under conditions approved by the District Board of Supervisors.

Section 7. Nothing in this ordinance shall be construed as prohibiting construction by Federal or State Governments necessary for national security or public health.

Section 8. The district Board of Supervisors is hereby authorized to request the State Soil Conservation Committee to appoint a Board of Adjustment, as provided in Section 109-313, O.C.L.A., consisting of three members who shall not be landowners in said district or of kin within the third degree to any person owning land in said district. Said Board of Adjustment shall have power to authorize variance from the terms of these land use regulations in accordance with substantial justice.

Section 9. Upon the approval of this ordinance by the favorable vote of three-fourths majority of all votes cast by landowners representing two-thirds of the land within the district approving the same, it shall immediately thereupon be in full force and effect.

NOW THEREFORE be it ordained by the landowners within the Warrenton Dune Soil Conservation District, and within the area known as Zone II, that:

Section 1. Erosion shall be controlled and the soil stabilized by vegetative and/or mechanical means on all lands of this area. After stabilization, continuous maintenance will be provided.

Section 2: Livestock may be grazed in the area with a permit from the Warrenton Dune Soil Conservation District Board of Supervisors. Livestock grazed within the area shall be confined by herding or fences to the land described in the permit, and the land shall not be grazed by a class of livestock, a greater number, or in excess of the period specified in the permit.

Section 3. Vehicular traffic and recurring equestrian traffic will be confined to hard surfaced (plant, gravel bound with clay, asphalt, concrete, or other material of like character) roads or trails.

Section 4. Vegetative cover specified by the Board of Supervisors of the district will be established where vegetation is destroyed during construction operations. All excavations, fills, or other disturbed land surfaces shall be prepared for planting and be planted to vegetation specified by the Board of Supervisors of the district during the planting period November through April immediately following such disturbance. After stabilization, continuous maintenance shall be provided.

Section 5. No other acts or land uses that result in destruction or serious deterioration of the ground cover will be permitted except under conditions by the Board of Supervisors of the district.

Section 6. The District Board of Supervisors is hereby authorized to request the State Soil Conservation Committee to appoint a Board of Adjustment, as provided in Section 109-313, O.C.L.A., consisting of three members who shall not be landowners in said district or of kin within the third degree to any person owning land in said district. Said Board of Adjustment shall have power to authorize variance from the terms of these land use regulations in accordance with substantial justice.

Section 7. Upon approval of this ordinance by the favorable vote of three-fourths majority of all votes cast by landowners representing two-thirds of the land within the district approving the same, it shall immediately thereupon be in full force and effect.

Clatsop County

In a recent hazardous area plan for the Clatsop Plains developed by Oregon State University (15) general policies and performance standards are presented for the dunes of the Clatsop Plains.

General Policies:

a. Uses which disturb vegetation that stabilize erodible areas shall be restricted.

b. Areas where the vegetation is disturbed by natural or man caused events shall be revegetated or protected by mechanical means as soon as possible.

c. Disturbance of the foredune by construction or excavation shall be prohibited.

d. Construction activities in erodible areas shall minimize the area in which vegetation is disturbed.

Performance Standards:

a. Area I

   1) Erosion shall be controlled and the soil stabilized by vegetative and/or mechanical means on all lands of the area. After stabilization continuous maintenance will be required.

b. Area II

   1) All regulations of the Clatsop County Soil and Water Conservation District for Zone II shall apply.

   2) Construction of any structures, utilities, or roads shall be kept to low density. Most of the land surface shall remain in vegetation.

c. Area III

   1) All regulations for Zone I of the Clatsop County Soil and Water Conservation District shall apply.

   2) No construction or excavation at any site is permitted without express approval of the Clatsop County Planning Commission (or their delegate) after their consultation with the Soil Conservation Service, District Conservationist.

d. Area IV

   1) All regulations of Zone I of the Clatsop County Soil and Water Conservation District shall apply.

   2) No new construction is permitted. Excavation is permitted only with permission of Clatsop County Planning Commission. The Planning Commission shall seek advice from the Soil Conservation Service and other professionals prior to their decision.

Procedures for Identification:

a. Existing reports and field investigations by qualified professionals shall be utilized wherever possible.

b. Any newspaper articles reporting damage to buildings, roads, or other facilities from wind blown sand shall be cut out and filed. Wherever possible, records or repair costs should be maintained. These areas shall be marked on a map.

c. Officials of the Clatsop County Soil and Water Conservation District and representatives of the Soil Conservation Service shall be contacted on at least a yearly basis concerning areas experiencing wind erosion. Any areas that they report as currently subject to severe wind erosion should be recorded on maps as Subject to Severe Wind Erosion with the date of the report. The Condition of all areas reported as Subject to Severe Wind Erosion should be checked on a yearly basis with officials of Clatsop County Soil and Water Conservation District and Soil Conservation Service as to their current status.

d. Where Clatsop County Soil and Water Conservation District officials deem wind erosion to be severe, and to threaten existing facilities, these areas will be marked on maps as Critical Wind Erosion Hazard Areas.

Public Lands

Extensive sand controls exist on some public lands on the Oregon coast. The major controlled and managed area is the recently established Oregon Dunes National Recreation Area (36), but other USFS and BLM lands are also managed for timber removal, dune access and use, and wildlife habitat.

State Wide Management

There are no existing state level regulations that apply specifically to sand dune stabilization. However, the OCC&DC has been in the process of developing policy proposals for the entire Oregon coast. The proposed policies of the Commission as of February 1975 are found in the OCC&DC Related Materials Appendix.

MANAGEMENT POTENTIAL

The sand dune mapping units used in this inventory have been rated in terms of their tolerance for specific activities (see Table 3). Is it apparent from Table 3 that two uses may have a high tolerance on a given mapping unit. Therefore, Table 4 shows activity capability or condition.

Table 3
Major Impacts in Management
Beaches and Ounes, Oregon

Mapping Units		Wildlife Habitat	Mining	Grazing	General Agriculture	Logging	Urban Oevelopment Oensity			Recreation				Water Table Alteration	Subsurface Oisposal	Filling	Road Construction	Vegetative Removal	Fire Hazard	Deep Excavation	Stream Undercutting	Ocean Undercutting	Oebris Removal (driftwood)	Vegetative Stabilization Enhancement (Chance of success0
										Undeveloped			Oeveloped											
Symbol	Name						Low	Med.	High	Pedestrian	ORV	Equestrian												
B	Beach	3	2A	-	-	-	0	0	0	3	3	3	0	-	0	0	0	-	1A	-	-	3A	3A	-
OC	Oune complex of OS, OSC, OS, and W	2	0	0	0	0	1	0	0	1'	0	0	0	1	2A	-	0	0	1	1	0	0	-	2
OS	Younger stabilized dunes	3	2	2	2	1	3	2	2	3	1	3	3	1	2A	2	2	2A	2	1	1	1	-	3
FO	Recently stabilized foredunes	3	0	0	0	0	1	0	0	2	0	1	0	1	1	-	1A	0	1	0	0	1	0	3
FOA	Active foredune	3	0	0	0	0	0	0	0	3	0	1	0	1	1	-	0	0	1	0	0	1	0	1
H	Active dune hummocks	3	0	0	0	0	0	0	0	3	0	3	0	1	0	-	1	0	2	0	0	0	-	1
OOS	Older stabilized dunes	3	2	2	2	2	3	3	3	3	2	3	3	2	1A	2	3	2A	2	2	2	2	-	3
OS	Open dune sand	1	3	-	-	-	0	0	0	3	3	3	0	2	3A	-	0	-	-	3	0	0	-	1-2
OSC	Open dune sand conditionally stable	1	0	0	0	0	1	0	0	1	0	0	0	1	2A	-	0	0	1	1	0	0	-	3
W	Wet interdune	3	1	1	1	1	1A	0	0	2C	0	1	1A	1A	0	0	1A	2	2	0	0	-	-	3
WDP	Wet deflation plain	3	0	1	3B	-	1A	0	0	2C	0	1	1A	0	0	0	1A	2	2	0	0	-	2A	3
IFO	Inland foredune	3	0	2	1	1	2	0	0	3	1	1	-	1	2A	-	2A	1A	2	2A	0	0	-	3
OFO	Older foredune	3	0	2	3A	3A	3	2	1	3	2	3	-	2	1-2A	-	3A	3A	2	3A	2	1	-	3

- Not applicable
0 No tolerance
1 Tolerance level low
2 Tolerance level medium
3 Tolerance level high
A Site Specific
B Specialty Crop
C Seasonal

TABLE 4

ACTIVITY COMPATIBILITY OR CONDITION

DESIGNATED ACTIVITY OR CONDITION

COMPETING CONDITION	Wildlife Habitat	Mining (Surface)	Grazing	General Agriculture	Logging	Low Density Urban	Medium Density Urban	High Density Urban	Undeveloped Ped. Rec.	Undeveloped ORV Rec.	Undeveloped Equ. Rec.	Developed Recreation	Water Table Alteration	Subsurface Disposal	Filling	Road Construction	Vegetative Removal	Fire Hazard	Deep Excavations	Stream Undercutting	Ocean Undercutting	Driftwood Removal	Vegetative Stabilization
Wildlife Habitat		0	1	1	1	1	1	0	2	1	1	0	-	-	1	1	0	0	0	0	0	1	1
Mining (Surface)	0		0	0	0	0	0	0	2	1	2	0	1	1	1	1	2	-	2	1	1	2	0
Grazing	1	1		1	1	0	0	0	2	0	2	0	-	-	0	0	0	1	1	0	0	2	1
General Agriculture	0	0	2		0	0	0	0	2	0	2	1	-	2	0	1	1	1	0	0	0	2	1
Logging	1	1	1	0		0	0	0	2	1	2	0	-	2	1	1	2	0	1	1	1	2	0
Low Density Urban	1	0	1	1	1		-	-	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
Medium Density Urban	0	0	0	0	0	-		-	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1
High Density Urban	0	0	0	0	0	-	-		1	0	0	1	1	1	1	1	1	0	0	0	0	1	0
Undeveloped Ped. Rec.	2	2	2	2	2	2	-	-		1	2	2	-	-	-	1	1	0	1	0	0	2	1
Undeveloped ORV Rec.	0	0	1	0	1	0	0	0	1		1	0	-	-	1	1	1	0	0	0	0	0	0
Undeveloped Equ. Rec.	2	2	2	1	2	1	1	0	2	1		1	-	-	1	1	1	0	1	0	0	2	0
Developed Recreation	0	0	0	0	0	1	0	0	2	0	1		-	1	1	1	1	0	0	0	0	1	1
Water Table Alteration	1	1	1	1	1	1	1	1	1	1	1	1		1	-	1	1	1	0	-	-	2	1
Subsurface Disposal	2	1	2	2	2	1	1	1	2	2	2	1	1		1	1	1	-	1	0	0	2	2
Filling	0	0	1	1	1	1	1	1	2	1	2	1	-	1		1	1	1	0	0	0	0	0
Road Construction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	0	0	1	1
Vegetative Removal	1	2	1	1	1	1	1	1	1	1	1	1	1	-	-	1		1	1	0	0	1	0
Fire Hazard	0	1	0	0	0	0	0	0	0	0	0	0	0	-	-	0	2		-	-	-	-	0
Deep Excavations	1	1	0	0	0	0	0	0	2	1	2	0	0	0	0	1	2	-		0	0	0	0
Stream Undercutting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0		-	-	0
Ocean Undercutting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	-		0	0
Driftwood Removal	1	0	1	1	1	1	1	1	1	0	1	1	-	-	0	1	1	0	0	0	0		1
Vegetative Stabilization	1	0	1	0	0	1	1	1	1	0	0	1	1	-	0	1	0	0	0	0	0	1	

- = Not Applicable
0 = Activities which conflict with the designated uses.
1 = Activities which may conflict with the designated use depending upon site characteristics and use intensities.
2 = Activities which do not hinder the designated use.

CONCLUSIONS

Beaches, sand spits, and sand dunes are a limited physical resource in Oregon with a variety of intensive and often conflicting uses. Analysis of the physical limitations of the resources will help resolve these conflicts.

Oregon's coastal beaches are the key resource in development of sand spits formed by littoral drift and sand dunes formed by wind action. The three resources are dependent on sand which is becoming increasingly in short supply.

Spits, beaches, and active dunes are dynamic landforms. They are not permanent features, but are in a perpetual state of formation, erosion, and rearrangement. Therefore, it is not surprising that some man-made features constructed on these dynamic landforms have been damaged. Proper site investigations would identify the hazards of construction in these areas.

Beaches and open sand dunes have a high natural appeal. These limited areas should be managed for their high recreational value. Located adjacent to these areas are fragile, areas, recently stabilized areas, and older stabilized areas, that should be adequately managed from overuse. Associated wet interdune areas provide critical waterfowl habitat.

The interdependence of beaches, spits, dunes, and wet interdune areas requires careful analysis before formulation of land use policies. The policies developed by OCC&DC were carefully formulated and are based on a consideration of the fragility, scarcity, and importance of the resource.

GLOSSARY

<u>Accretion</u>: Any growth or increase in size, especially by gradual external addition.

<u>Active Dune</u>: A sand dune which is growing or moving, or both, as a result of wind action. There is a broad range of active dune forms such as transverse dunes, oblique dunes, parabolas, active hummocks, or active foredunes.

<u>Active Foredune</u>: A growing barrier ridge of sand immediately above the high tide line and paralleling the beach. They have usually formed as a new dune on a low beach ridge with a log debris base and are receiving such a substantial sand supply that the vegetation is predominately beachgrass. As observed during this inventory, they generally have greater than 15 percent open sand patches along the crest of the active foredunes during the summer, and generally greater than 40 percent open sand patches during winter months.

<u>Active Sand Area</u>: A sand area which is growing or moving, or both, as a result of wind action. There is a broad range of active sand areas such as transverse dunes, oblique dunes, parabolas, active hummocks, and active foredunes.

<u>Aeolian</u>: Deposits arranged by the wind, such as sands and other loose materials along shores (1).

<u>Arkose</u>: A rock of granular texture, formed principally by mechanical aggregation (1). Arkosic is an adjective referring to a granular of sandy texture.

<u>Active Dune Hummocks</u>: Hummocks that are actively growing in size by sand accumulation or decreasing in size by deflation (wind erosion). They generally occur above the water table but wet areas are common.

Appropriate Authority: An agency or unit of government at the local, state, or federal level that has the responsibility and authority to take a specified action. The most suitable agency or unit of government will be determined at a later date by the OCC&DC and will be recommended to the Legislature as part of the coastal zone management program.

Back Dune: Older ridge of sand behind foredune, deflation plain, and tree line having a soil base suitable for shrubs and trees.

Beach: Gently sloping zones of loose sand that extend from the low-water line to a point where there is a definite change in material type or landform.

Black Sands: Local deposits of heavy minerals concentrated by wave and current action on beaches. The heavy minerals consist largely of magnetite, ilemenite, and hematite associated with minerals such as garnet, rutile, zircon, chromite, amphiboles, and pyroxenes.

Blowout: A more or less elongate deflation trough-shaped body adjoining an accumulation area formed on pre-existing vegetated dune.

Breaching: To make a hole or gap through an area such as a foredune.

Bulkheads: Wave resistant walls of various types along shorelines (34). Bulkheads are constructed of steel, timber, or concrete piling. Unless combined with other types of protection, the bulkhead eventually is changed to a massive seawall capable of withstanding the direct force of the waves (34). Seawalls may have vertical, curved, or stepped faces.

Carrying Capacity: The maximum capability of an existing environment, and the resources of environment to indefinitely support a certain population or activity level.

Coastal Terrace: Former strandlines of the sea that represent records of landward progress of littoral erosion and deposition (1).

Delft Scanning Stereoscope: The ODSS III Scanning Stereoscope serves for stereoscopic viewing as well as scanning of 10" x 9" and 10" x 18" photographs without the necessity of shifting the photographs during operations.

Drift Sectors: The interactive areas in which local shoreline and headland erosion and the accretion process are confined. Erosion from a sand quarry or feeder bluff passes through a drift sector to the accretion area.

Drowned Valleys: Valleys of a dissected land surface, the lower parts of which have been inundated by the sea as a result of submergence of the land margin (1).

Dune Complex: Various patterns of small dunes with partially stabilized intervening areas.

Estuary: A tidal bay or arm of the sea where freshwater from streams and rivers mix with saltwater from the sea and which includes: (1) estuarine waters; (2) eel grass beds; (3) tidelands; and (4) coastal tide marshes.

Foredune: An active foredune that has become conditionally stable with regard to wind erosion.

Flood Plain: The area adjoining a river, stream, watercourse, ocean, bay, or lake which has been inundated by a flood or can be reasonally expected to be so inundated in the future.

Fragile Sand Area: An area of sand that is fragile because of poor vegetative cover, size, degree of slope, or wind exposure.

Geomorphic: Of or pertaining to the landforms of the earth (1).

Heavy Minerals: The accessory detrital minerals of a sedimentary rock of high specific gravity (1).

Hillock: Mound of sand that accumulates around grass which builds mound higher.

Hummock: Partly vegetated, usually with beachgrass, circular, and elevated mounds of sand. These mounds may be called active hummocks or wet hummocks.

Igneous Rocks: Formed by solidification of hot magma (1).

Interdune Area: Low-lying areas between higher landforms which are generally under water during part of the year.

Littoral Current: Currents generated by waves breaking at an angle to the shoreline, which move usually parallel to, and adjacent to, the shoreline within the surf zone.

Littoral Drift: The material (gravel, sand, etc.) moved in the littoral zone under the influence of waves and currents (1).

Littoral Zone: The zone embraced between the average of the highest flood and the average of the lowest ebb tides of the months (1). Of shore origin as contrasted to deep water areas.

Longshore Current: The inshore current moving parallel to the shore. These currents carry sand (longshore transport) that has been stirred into suspension by the breaking waves.

Marine Terrace: A nearly level to undulating geomorphic surface with a seaward slope formed mainly by wave erosion and beach deposition during a period when the land remained static, but which has subsequently been elevated above the beach. The beach and near shoreline sand deposits of the marine terrace are generally modified by aeolian dune activity, once these deposits occur above high tide inundation.

Metamorphosed: Any change in the texture or composition of a rock after its induration or solidification, produced by exterior agencies especially by pressure and by temperature changes.

Net Social Benefits: Net social benefits are social benefits less social costs.

Older Foredune:	A wind stable former foredune that lies approximately parallel, but back from the beach, and which has been underlain by soils with weakly cemented nodules and lenses to strongly cemented Bir horizons. Older foredunes could be included in the older stabilized dune mapping unit, but are separated because of identifiable foredune landforms.
Older Stabilized Dune:	A wind stable dune that has soils with weakly cemented nodules and lenses to strongly cemented nodules or strongly cemented Bir horizons. Vegetation on this landform is native grass, Douglas-fir, western hemlock, sitka spruce, and shore pine.
Open Dune Sand:	Wind drifted sand in the form of dunes and ridges that are essentially bare of vegetation.
Open Dune Sand Conditionally Stable:	A sand dune presently in a wind stable condition, but vulnerable to becoming active due to being overlain by fragile plantings.
Open Space:	Land used for agricultural, forest purposes, or any land area whose preservation would: (1) Conserve and enhance natural or scenic resources; (2) Protect air, stream, or water supply; (3) Promote conservation; (4) Conserve landscaped areas; (5) Enhance the value to the public of abutting or neighboring areas; (6) Enhance recreation opportunities; (7) Preserve historic sites; or (8) Promote orderly urban or suburban development.
Plant Community:	The aggregation or association of plant species that, alone or together, have the same ecological requirements (36).
Plant Succession:	The gradual and continuous replacement of one kind of plant by another until the community is replaced by another that is more complex.

Policy: A guiding principle for a course of action which will lead toward achieving an objective or goal. A statement upon which coastal zone management decisions can be based.

Precipitation Ridge: An open sand ridge due to precipitation of sand at the edge of the forest. Usually formed by coalescence of active dune forms.

Public Benefits (or Losses): Those combined social, economical, and environmental gains, or losses, which accrue to, or are taken from, the public because of a use or activity and its subsequent resulting effects.

Recommended Action: Means of achieving an objective or implementing a policy.

Sand Areas: Sand landforms which are grouped into beaches, active, recently stabilized, interdune, and older stabilized areas.

Sand Dune: Hill or ridge of sand piled up by the wind along sandy coasts.

Sand Quarry (Feeder Bluff): Source area for sand for building beaches and spits. Sand supply areas are usually sandstone formations.

Sand Spit: A small point of land or narrow shoal composed of sand and projecting from the shore into a body of water.

Shoal: A part of the area covered by water, of a sea, lake, or river, when the depth is little (1).

Shorelands: Those areas adjacent to a lake, stream, estuary, or ocean which have a direct and significant relationship to the water. These areas are generally identified on the basis of direct or immediate drainage of ground and surface waters into a major coastal water body. Specific identification of shorelands on maps may be based on landforms which affect or are affected by the action of the water.

Shorelines: The non-submersible land area immediately adjacent to a body of water.

Shore Process Corridor: A zonal belt which is bounded on the landward side or sides by the extreme surge-limits of river, estuarine, lake, and marine waters; and, where they exist, those aquatic and terrestial outer fringes on each side that can affect or are affected by the action of the water. The Shore Process Corridor contains shorelands, and features of the watercourse.

Significant Habitat Areas: A land or water area where sustaining the natural resource characteristics is important or essential to the production and maintenance of identifiable species of aquatic life or wildlife populations.

Social Benefits: Social benefits are favorable or positive effects on one or more of the following values: aesthetic, cultural, historic, ecological, recreational, and economic. Social benefits can accrue to individuals and to groups of individuals including society as a whole. Social benefits may be tangible, pecuniary, or nonpecuniary, and they need not be measured by numerical data.

Social Costs: Social costs are those explicit cost outlays made by private individuals, firms and organizations, and public institutions and organizations, plus those implicit costs stemming from foregone opportunities for factors that might otherwise be used in alternative ways or activities. Social costs may be tangible or intangible, pecuniary or nonpecuniary, and they need not be measured by numerical data.

Stability: Resistance to change or movement. In sand areas this refers to the role of vegetative cover or mechanical means in protecting the landform from movement.

Stabilization: The process of controlling sand activity (i.e., stilling the movement of sand) by natural vegetative growth, planting of grasses and shrubs, or mechanical means (e.g., wire net, fencing, oil).

<u>Stabilized Dune</u>: A dune protected by vegetation from further movement or modification by the wind.

<u>Taxonomy</u>: The science of classification or the laws and principles covering the classifying of objects.

<u>Tertiary</u>: The earlier of the two geologic periods comprised in the Cenozoic era.

<u>Tsunami</u>: A seismic sea wave created by a submarine earthquake abruptly elevating and lowering the sea bottom or creating a submarine landslide.

<u>Wet Deflation Plain</u>: The broad interdune area which is wind scoured to the height of the summer water table.

<u>Wet Hummocks</u>: Hummocks that are not significantly increasing or decreasing in size, and which have a water table at or near the surface during winter months and 1-3 feet below the surface during summer months.

<u>Wet Mountain Front</u>: The wet area between the dune mapping units and the mountain front scarp. The areas are essentially entrapments of runoff water between the mountain runoff area and a landward advance or stabilized dunes.

<u>Wet Surge Plains</u>: The portion of the estuary from lowest tide to the drift line of the highest tide.

<u>Younger Stabilized Dune</u>: A youthful wind stable dune that has weakly developed sandy soils with little or no development of cemented nodules or lenses of Bir horizons. Vegetation on this landform is native grass. European beachgrass, shrubs such as scotch broom and tree lupine, and trees such as shore pine and red alder.

SOIL INTERPRETATIONS APPENDIX

ACTIVE DUNELAND

WESTPORT SERIES

NETARTS SERIES

DATE: January, 1974 GBT, GEO *Active Dune Land* SERIES SOILS: 1. *Active Dune Land*

This land type consists of wind-drifted sand in the form of dunes, ridges, or hummocks. The material is not stabilized and has no vegetation established on it. Dunes are generally 5 to 40 feet high; they have a maximum elevation of about 180 feet. The relief is a succession of irregularly distributed dunes and ridges, which rise above the intervening wind-formed valleys and swales. Dunes are bare of vegetation or the growth is not dense enough to protect the sand and to prevent it from blowing. The dunes are constantly shifting under the influence of strong ocean winds. Elevation is 0 to about 180 feet. Average annual precipitation is 60 to 80 inches, average annual temperature is 50 to 52°F.; and the frost-free period is about 202 days. Active Dune Land consists of grayish-brown, single grained, porous sand and fine sand.

This land type is used primarily for wildlife habitat and recreation. This soil occurs in the Coast Range and Valley Resource Area (A1).

(Classification: Entisol)

ESTIMATED SOIL PROPERTIES

DEPTH FROM SURFACE (in.)	CLASSIFICATION			COARSE FRACT. OVER 3 IN.	% OF MATERIAL PASSING SIEVE				LIQUID LIMIT	PLASTICITY INDEX	PERMEABILITY (in/hr)	AVAIL. WATER CAP. (in/in)	SOIL REACTION (pH)	SHRINK SWELL POTENTIAL
	USDA TEXTURE	UNIFIED	AASHO		#4	#10	#40	#200						
0-72	Fine sand or sand	SM-SP	A-2	0	100	100	60-75	10-30	Nonplastic		6.0->20.0	.05-.07	4.6-5.0	Low

DEPTH (in.)	CONDUCTIVITY (mmhos/cm)	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUPS
0-72	-	Low	High	-	5	1

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (ft.)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	HYDROLOGIC GROUP
None			> 6			A

CEMENTED PAN DEPTH (in.)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (in.)	BEDROCK HARDNESS	FROST ACTION	REMARKS
-		> 60		-	

SANITARY FACILITIES AND COMMUNITY DEVELOPMENT

USE	SOIL	RATING	RESTRICTIVE FEATURES
SEPTIC TANK ABSORPTION FIELDS	1	Severe	Percolates rapidly
SEWAGE LAGOONS	1	Severe	Percolates rapidly
SANITARY LANDFILL (TRENCH)	1	Severe	Percolates rapidly
SANITARY LANDFILL (AREA)	1	Severe	Percolates rapidly
DAILY COVER FOR LANDFILL	1	Poor	Too sandy
SHALLOW EXCAVATIONS	1	Severe	Too sandy
DWELLINGS WITHOUT BASEMENTS	1	Slight to severe	Slope
DWELLINGS WITH BASEMENTS	1	Slight to severe	Slope, soil blowing
SMALL COMMERCIAL BUILDINGS	1	Slight to severe	Slope, soil blowing
LOCAL ROADS AND STREETS	1	Severe	Soil blowing

SOURCE MATERIAL AND WATER MANAGEMENT

USE	SOIL	RATING	RESTRICTIVE FEATURES
ROADFILL	1	Good	
SAND	1	Fair	Excess fines
GRAVEL	1	Unsuited	Excess fines
TOPSOIL	1	Poor	Too sandy
POND RESERVOIR AREA	1	Severe	Percolates rapidly
EMBANKMENTS DIKES AND LEVEES	1	Severe	Low strength, piping, percolates rapidly
DRAINAGE	1		Not needed
IRRIGATION	1		Not needed
TERRACES AND DIVERSIONS	1		Not needed
GRASSED WATERWAYS	1		Not needed

Active Dune Land SERIES

RECREATION

USE	SOIL	RATING	RESTRICTIVE FEATURES	USE	SOIL	RATING	RESTRICTIVE FEATURES
CAMP AREAS	1	Severe	Too sandy, soil blowing	PLAYGROUNDS	1	Severe	Too sandy, soil blowing
PICNIC AREAS	1	Severe	Too sandy, soil blowing	PATHS AND TRAILS	1	Severe	Too sandy, soil blowing

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

SOIL	CAPABILITY														REMARKS
	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	
1	VIIIe														

WOODLAND SUITABILITY

SOIL	POTENTIAL PRODUCTIVITY		WOOD SUIT. GROUP	MANAGEMENT PROBLEMS					NATIVE SPECIES
	SPECIES	SITE INDEX		EROSION HAZARD	EQUIPMENT LIMIT.	SEEDLING MORTALITY	WINDTHROW HAZARD	PLANT COMPET.	
	None								

WINDBREAKS

SOILS	SPECIES	HT. AGE 20	PERFOR-MANCE	SPECIES	HT. AGE 20	PERFOR-MANCE	SPECIES	HT. AGE 20	PERFOR-MANCE
	None								

WILDLIFE HABITAT SUITABILITY

SOIL	POTENTIAL FOR HABITAT ELEMENTS								POTENTIAL AS HABITAT FOR:			
	GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
1	Very poor	Very poor	Poor	-	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	-

RANGELAND

RANGE SITE NAME	SOIL	KEY SPECIES AND % COVER	POTENTIAL YIELDS		NORMAL SEASON	
			TOTAL lb/Ac	USABLE Ac/AUM	GROWING	GRAZING
		None				

FOOTNOTES

DATE: 1/74 GBT-GEO WESTPORT SERIES SOILS:

1. *Westport fine sand, 0 to 12 percent slopes*
2. *Westport fine sand, 0 to 20 percent slopes*
3. *Westport fine sand, 12 to 30 percent slope*
4. *Westport fine sand, 30 to 70 percent slope*
5. *Westport loamy sand, 0 to 12 percent slope*
6. *Westport loamy sand, 12 to 30 percent slop*
7. *Westport-Yaquina loamy sands, 0 to 30 percent slopes*
8. *Westport-Duneland complex, 12 to 30 percen slopes*

The Westport series consists of deep, excessively drained soils that formed in wind-deposited material on nearly level to steep stabilized dunes. The vegetation is Sitka spruce, shore pine, manzanita, evergreen huckleberry, dune grass, forbs and other shrubs. Elevation is 0 to 300 feet. Average annual precipitation is 60 to 100 inches; average annual air temperature is 50 to 53° F. The frost-free period at 32° F. is 200 to 250 days.

A mat of mosses, litter and roots is on top of the mineral soil. Typically, the surface layer is very dark grayish-brown and dark grayish-brown fine sand to loamy fine sand about 16 inches thick. The subsoil is brown to olive gray fine sand to depths greater than 60 inches.

Permeability is very rapid. Runoff is slow from all units. The erosion hazard is high for all units, assuming the vegetation is removed. The total available water holding capacity is 3 to 4 inches. The water supplying capacity is 18 to 20 inches. Effective rooting depth is over 60 inches.

Westport soils are used for homesites, wildlife habitat, and recreation. These soils are in the Northern Pacific Coast Range and Valleys Land Resource Area (MLRA-A1).

(Classification: Typic Udipsamments; mixed, mesic family)

ESTIMATED SOIL PROPERTIES

DEPTH FROM SURFACE (in.)	CLASSIFICATION USDA TEXTURE	UNIFIED	AASHO	COARSE FRACT. OVER 3 IN.	% OF MATERIAL PASSING SIEVE #4	#10	#40	#200	LIQUID LIMIT	PLASTICITY INDEX	PERMEABILITY (in/hr)	AVAIL. WATER CAP. (in/in)	SOIL REACTION (pH)	SHRINK SWELL POTENTIAL
0-60	fine sand	SM	A-2	0	100	100	65-80	20-35	non-plastic		6.0->20.0	.05-.07	5.1-6.0	low

DEPTH (in.)	CONDUCTIVITY (mmhos/cm)	CORROSIVITY STEEL	CONCRETE	EROSION FACTORS K	T	WIND EROD. GROUPS
0-60	-	Low	Moderate	-	5	1

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (ft.)	KIND	MONTHS	HYDROLOGIC GROUP
none			> 6			A

CEMENTED PAN DEPTH (in.)	HARDNESS	BEDROCK DEPTH (in.)	HARDNESS	FROST ACTION	REMARKS
-		>60		-	

SANITARY FACILITIES AND COMMUNITY DEVELOPMENT

USE	SOIL	RATING	RESTRICTIVE FEATURES
SEPTIC TANK ABSORPTION FIELDS 1/	1,5 2,7 3,4,6,8	Slight-Mod Slight to Severe Severe	Slope Slope Slope
SEWAGE LAGOONS 1/	1,2,3,4,5,6,7,8	Severe	Percolates rapidly, slope
SANITARY LANDFILL 1/ (TRENCH)	1,2,3,4,5,6,7,8	Severe	Percolates rapidly, too sandy, slope
SANITARY LANDFILL 1/ (AREA)	1,5 2,3,4,6,7,8	Severe Severe	Percolates rapidly Percolates rapidly, slope
DAILY COVER FOR LANDFILL	1,5 2,3,4,6,7,8	Poor Poor	Too sandy Too sandy, slope
SHALLOW EXCAVATIONS	1,2,5 3,4,6,7,8	Severe Severe	Too sandy Too sandy, slope
DWELLINGS WITHOUT BASEMENTS	1,2,5 3,4,6,7,8	Moderate Severe	Slope Slope
DWELLINGS WITH BASEMENTS	1,2,5 3,4,6,7,8	Moderate Severe	Slope Slope
SMALL COMMERCIAL BUILDINGS	1,2,3,4,5,6,7,8	Severe	Slope
LOCAL ROADS AND STREETS	1,5 3,6 2,4,7,8	Slight Moderate to Severe Severe	- Slope Slope

SOURCE MATERIAL AND WATER MANAGEMENT

USE	SOIL	RATING	RESTRICTIVE FEATURES
ROADFILL	1,5 3,6 2,4,7,8	Good Fair-Poor Poor	- Slope Slope
SAND	1,2,3,4,5,6,7,8	Poor	Excess fines
GRAVEL	1,2,3,4,5,6,7,8	Unsuited	Excess fines
TOPSOIL	1,2,3,4,5,6,7,8	Poor	Too sandy
POND RESERVOIR AREA	1,2,3,4,5,6,7,8	Severe	Percolates rapidly
EMBANKMENTS DIKES AND LEVEES	1,2,3,4,5,6,7,8	Severe	Piping, percs rapidly
DRAINAGE	1,2,3,4,5,6,7,8	-	Not needed
IRRIGATION	1,2,3,4,5,6,7,8	-	Not needed
TERRACES AND DIVERSIONS	1,2,3,4,5,6,7,8	-	Not needed
GRASSED WATERWAYS	1,2,3,4,5,6,7,8	-	Not needed

CONTINUATION SHEET OR-SOILS-1 12/72 WESTPORT SERIES

RECREATION

USE	SOIL	RATING	RESTRICTIVE FEATURES	USE	SOIL	RATING	RESTRICTIVE FEATURES
CAMP AREAS	1,5 2,3,4,6,7,8	Moderate Severe	Too sandy Slope	PLAYGROUNDS	1,2,3,4,5,6,7,8	Severe	Too sandy, slope
PICNIC AREAS	1,5 2,3,4,6,7,8	Moderate Severe	Too sandy Slope	PATHS AND TRAILS	1,2,3,5,6,7,8 4	Severe Severe	Too sandy Slope, too sandy

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

SOIL	CAPABILITY		Pasture AUM/Ac												REMARKS
	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	
1,5	VIe		1	3											
2,3,4,6,7,8	VIIe		-	1											

WOODLAND SUITABILITY

SOIL	POTENTIAL PRODUCTIVITY		WOOD SUIT. GROUP	MANAGEMENT PROBLEMS					NATIVE SPECIES
	SPECIES	SITE INDEX		EROSION HAZARD	EQUIPMENT LIMIT.	SEEDLING MORTALITY	WINDTHROW HAZARD	PLANT COMPET.	
1,2,3,4,5,6,7,8	Sitka spruce	-	-	Severe	Severe	High	High	Slight	Sitka spruce, shore pine

WINDBREAKS

SOILS	SPECIES	HT. AGE 20	PERFORMANCE	SPECIES	HT. AGE 20	PERFORMANCE	SPECIES	HT. AGE 20	PERFORMANCE
1,2,3,4,5,6,7,8	Shore pine	30	Fair	Sitka spruce	30	Fair			

WILDLIFE HABITAT SUITABILITY

SOIL	POTENTIAL FOR HABITAT ELEMENTS								POTENTIAL AS HABITAT FOR:			
	GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
1,2,3,5,6,7,8	Poor	Poor	Fair	-	Poor	Poor	V.poor	V.poor	Poor	Poor	V.poor	-
4	V.poor	V.poor	Fair	-	Poor	Poor	V.poor	V.poor	Poor	Poor	V.poor	-

RANGELAND

RANGE SITE NAME	SOIL	KEY SPECIES AND % COVER	POTENTIAL YIELDS		NORMAL SEASON	
			TOTAL lb/Ac	USABLE Ac/AUM	GROWING	GRAZING
None						

FOOTNOTES

1/ Ground water pollution hazard

DATE: March 1974 GEO *Netarts* SERIES SOILS:

1. *Netarts fine sandy loam, 7-30% slopes*
2. *Netarts sandy loam, 0-12% slopes*
3. *Netarts sandy loam, 12-40% slopes*
4. *Netarts loamy fine sand, 0-30% slopes*

The Netarts series consists of well drained soils formed on old stabilized sand dunes. Slopes are 7 to 30 percent. Where not cultivated, the vegetation is shore pine, sitka spruce, salal, huckleberry, rhododendron and manzanita. Elevation is 50 to 200 feet. Average annual precipitation is 80 to 100 inches, average annual air temperature is about 52°F. and the frost-free period is about 180 to 210 days.

The surface layer is fine sandy loam and loamy fine sand about 13 inches thick. The subsoil is fine sand about 39 inches thick. The substratum is fine sand many feet thick.

Permeability is moderately rapid. Runoff is slow; the wind erosion hazard is severe. The total available water holding capacity is 3.5 to 5.0 inches. Water supplying capacity is 20 to 24 inches. The effective rooting depth is over 60 inches.

These soils are used mainly for forestry, homesites, and recreation. They are in the Coast Range and Valleys Resource Area (A1).

(Classification: Entic Haplorthods; sandy, mixed, mesic family).

ESTIMATED SOIL PROPERTIES

DEPTH FROM SURFACE (in.)	CLASSIFICATION USDA TEXTURE	UNIFIED	AASHO	COARSE FRACT. OVER 3 IN.	% OF MATERIAL PASSING SIEVE #4	#10	#40	#200	LIQUID LIMIT	PLASTICITY INDEX	PERMEABILITY (in/hr)	AVAIL. WATER CAP. (in/in)	SOIL REACTION (pH)	SHRINK SWELL POTENTIAL
0-13	Loamy fine sand	SM	A-2	0	100	85-100	65-80	20-35	-	NP	2.0-6.0	.09-.10	4.5-5.0	Very low
13-52	Fine sand	SM	A-2	0	100	85-100	55-70	15-30	-	NP	2.0-6.0	.05-.07	5.1-5.5	Very low
52-65	Fine sand	SM	A-2	0	100	100	60-75	20-30	-	NP	6.0- >20.0	.05-.07	5.1-5.5	Very low

DEPTH (in.)	CONDUCTIVITY (mmhos/cm)	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	T	WIND EROD. GROUPS	FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (ft.)	KIND	MONTHS	HYDROLOGIC GROUP
0-13	-	High	High	.17	5	2	None			> 6			A
13-52	-	High	High	.20									
52-65	-	High	High	.20									

CEMENTED PAN DEPTH (in.)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (in.)	BEDROCK HARDNESS	FROST ACTION	REMARKS
-		> 60		-	

SANITARY FACILITIES AND COMMUNITY DEVELOPMENT				SOURCE MATERIAL AND WATER MANAGEMENT			
USE	SOIL	RATING	RESTRICTIVE FEATURES	USE	SOIL	RATING	RESTRICTIVE FEATURES
SEPTIC TANK ABSORPTION FIELDS 1/	2 1,4 3	Slight to moderate Moderate to severe Severe	Slope Slope Slope	ROADFILL	2 1,3,4	Slight Moderate to severe	Slope
SEWAGE LAGOONS 1/	1,2,3,4	Severe	Slope, percolates rapidly	SAND	1,2,3,4	Poor	Excessive fines
SANITARY LANDFILL (TRENCH) 1/	2 1,3,4	Severe Severe	Percolates rapidly Slope, percolates rapidly	GRAVEL	1,2,3,4	Unsuited	Excessive fines
SANITARY LANDFILL (AREA) 1/	2 1,3,4	Severe Severe	Percolates rapidly Slope, percolates rapidly	TOPSOIL	1,2,3,4	Poor	Too sandy
DAILY COVER FOR LANDFILL	2 1,4 3	Fair Fair to poor Poor	Slope, too sandy Slope, too sandy Slope	POND RESERVOIR AREA	1,2,3,4	Severe	Percolates rapidly
SHALLOW EXCAVATIONS	2 1,3 4	Slight to moderate Moderate to severe Severe	Slope Slope Too sandy, slope	EMBANKMENTS DIKES AND LEVEES	1,2,3,4	Moderate	Piping, percolates rapidly
DWELLINGS WITHOUT BASEMENTS	2 1,3,4	Slight to moderate Moderate to severe	Slope Slope	DRAINAGE	1,2,3,4		Not Needed
DWELLINGS WITH BASEMENTS	2 1,3,4	Slight to moderate Moderate to severe	Slope Slope	IRRIGATION	1,2,3,4	Unsuited	Droughty
SMALL COMMERCIAL BUILDINGS	2 1,3,4	Slight to severe Severe	Slope Slope	TERRACES AND DIVERSIONS	1,2,3,4		Not Needed
LOCAL ROADS AND STREETS	2 1,3,4	Slight Moderate to severe	 Slope	GRASSED WATERWAYS	1,2,3,4		Not Needed

RECREATION

USE	SOIL	RATING	RESTRICTIVE FEATURES	USE	SOIL	RATING	RESTRICTIVE FEATURES
CAMP AREAS	2 1,4 3	Slight to moderate Moderate to severe Severe	- Slope - Slope, too sandy Slope	PLAYGROUNDS	2 1,3,4	Slight to severe Severe	Slope Slope
PICNIC AREAS	2 1,4 3	Slight to moderate Moderate to severe Severe	- Slope - Slope, too sandy Slope	PATHS AND TRAILS	2 1,3,4	Slight Moderate to severe	Slope

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

SOIL	CAPABILITY														REMARKS
	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	NIRR	IRR	
1,3,4	VIIe														
2	VIe														

WOODLAND SUITABILITY

SOIL	POTENTIAL PRODUCTIVITY		WOOD SUIT. GROUP	MANAGEMENT PROBLEMS					NATIVE SPECIES
	SPECIES	SITE INDEX		EROSION HAZARD	EQUIPMENT LIMIT.	SEEDLING MORTALITY	WINDTHROW HAZARD	PLANT COMPET.	
1	Sitka spruce	150 (est)	20	Severe	Slight	Slight to moderate	Slight to moderate	Slight	Sitka spruce, shore pine

WINDBREAKS

SOILS	SPECIES	HT. AGE 20	PERFORMANCE	SPECIES	HT. AGE 20	PERFORMANCE	SPECIES	HT. AGE 20	PERFORMANCE
1,2,3,4	Shore Pine	35-40	Fair	Sitka Spruce	35-40	Fair	Western Red Cedar	35-40	Fair

WILDLIFE HABITAT SUITABILITY

SOIL	POTENTIAL FOR HABITAT ELEMENTS								POTENTIAL AS HABITAT FOR:			
	GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
1	Very poor	Very poor	Fair	-	Poor	Good	Very poor	Very poor	Poor	Poor	Very poor	-

RANGELAND

RANGE SITE NAME	SOIL	KEY SPECIES AND % COVER	POTENTIAL YIELDS		NORMAL SEASON	
			TOTAL lb/Ac	USABLE Ac/AUM	GROWING	GRAZING
	1	None				

FOOTNOTES

1/ Ground water pollution hazard

OREGON COASTAL CONSERVATION AND DEVELOPMENT COMMISSION RELATED MATERIALS APPENDIX

BEACHES AND DUNE RESOURCES OF THE OREGON COASTAL ZONE

INTRODUCTION

The beaches and dunes of the Oregon coast have been identified as resources[17] which must be managed in order to achieve the adopted goal of OCC&DC. Specifically, the management of sand area resources is essential to assure:

(1) the preservation, conservation, development and restoration of these resources;

(2) the greatest benefits to this and succeeding generations of Oregonians;

(3) the control of pollution and the prevention of irreversible damage to the ecological and environmental qualities; and

(4) protection of the unique character of life on the coast reflected in cultural, historic and aesthetic values.

PURPOSE

Because of diverse values and the highly dynamic character of sand area processes, these resources offer both opportunities and constraints to human activity. Some uses are detrimental to the natural sand processes and there are conflicts between users of sand areas. To resolve these conflicts and assure the continued integrity of sand area values for this and future generations it is necessary that these areas be properly managed through appropriate land use decisions. Therefore, the policies recommended for adoption by the State are intended to:

(1) protect the essential social, economic and environmental values provided by sand areas; and

(2) provide a means for incorporating sand area resource considerations into the comprehensive planning and regulatory process at the State and local level.[18]

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[17]On August 9, 1974, OCC&DC adopted a staff report containing a section entitled "Structure of the Management Program". This structure included policy categories for (1) land and water resources; (2) coastal values; (3) economic needs; and (4) constraints on coastal zone management.

[18]After adoption by the State of Oregon and approval by the U.S. Secretary of Commerce, Federal agency actions will have to be in compliance with the coastal zone management program. Therefore, the essential involvement of the Federal government is considered to be part of actions prefaced with "State and local government". The U.S. Forest Service in its administration of the "Dunes" National Recreation Area may vary from the program in order to carry out its responsibilities.

POLICIES

1. Maintain Values and Uses of Sand Areas (Beaches[19] and Dunes)

Policy Statement

State and local government shall maintain or enhance the values[20] of Oregon's sand areas[21] by assuring that public and private uses do not exceed the physical and biological limitations[22] of these areas. (B&D 12)

Necessary Actions

a. *Local government shall include within their comprehensive plans an identification of the various types of sand areas (as identified in the OCC&DC Beaches and Dunes Inventory.) and shall designate for each type of sand area uses that do not exceed the physical and biological limitations peculiar to each type of sand area.*

b. *The State of Oregon, in cooperation with local units of government and with the requested assistance of the U.S. Soil Conservation Service, shall develop planning criteria[23] for sand areas and shall require that these criteria be used in the local comprehensive planning process as well as in state agency programs.*

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[19]Public recreational use regulations and values at all beaches are controlled by the Oregon Beach Law (Act 601 - 1967) which affirms the public right to use of the beaches (waterline to vegetation line). This law is administered by the State Parks and Recreation Office and includes the following requirements:

(a) Improvements on beaches; removal of sand, rock, mineral, marine growth and other natural products; and laying of pipe, cable, or conduit across beaches require permits. Permits are based on the following considerations, among others:

(1) The public need for healthful, safe, aesthetic surroundings and conditions; the natural scenic, recreational and other resources of the area; and the present and prospective need for conservation and development of those resources.

(2) The physical characteristics or the changes in the physical characteristics of the area and the suitability of the area for particular uses and improvements.

(3) The land uses, including public recreational use if any, and the improvements in the area, the trends in land uses and improvements, the density of development and the property values in the area.

(4) The need for recreation and other facilities and enterprises in the future development of the area and the need for access to particular sites in the area. (1969 c.601,11)

(b) No deposit of debris, logs, rubbish, or refuse is allowed.

(c) Use of motor vehicles or aircraft on beaches is restricted to varying degrees along the coast.

[20]Sand area values include: areas of significant wildlife habitat; storage and recharge of groundwater; aesthetics; foredune protection of property and environment from wind erosion, high tides, storms and tsunamis; and opportunities for recreation and development.

[21]Sand areas can be classified into four categories: active, recently stabilized, interdune, and stabilized. Active sand areas include: beaches, open sand dunes (oblique, parabolas and transverse dunes), hummocks, and active foredunes; recently stabilized sand areas include: conditionally stable foredunes, inland foredunes, conditionally stable open sand dunes, younger stabilized dunes and dunes complexes (the latter which evidences a variety of forms within a small area); interdune sand areas include: deflation plains and wet interdune areas (in some cases lakes, streams, flood plains and surge plains are also interdune forms but they are excluded from this definition because these are addressed in other resource categories); stabilized sand areas include older stabilized dunes and older foredunes. Sandspits are not identified as a separate type because they may have the characteristics of all categories.

[22]In the OCC&DC Beaches and Dunes Inventory (Beaches and Dune Resources of the Oregon Coast) a total of twenty different types of sand landforms were identified and discussed. The distinguishing characteristics of each landform type are evaluated in regard to their suitability for recreation, development, wildlife habitat and a wide range of human activities. The tolerance ratings for specific activities and matrix of activity compatibility presented for each landform (Tables 3 and 4, Beaches and Dune Inventory) provide basic information for assessing the physical and biological limitations (the stability of the landform is generally of paramount importance) of a sand area for a particular use.

[23]Criteria would include guidelines and procedures to follow in designating sand areas for particular uses. The OCC&DC inventory Beaches and Dune Resources of the Oregon Coast and the policies and recommended actions addressing this resource category represent the first steps in developing this criteria.

Background

Long shore currents, sand supply, wave action, vegetation and wetness are the principle natural processes influencing the sand area resource. Littoral drift[24] is deposited on the beach by currents and wave action. As this beach sand dries, it is carried inland by the wind. European beachgrass and other plants which have established themselves in the open sand up to the normal storm tideline reduce the velocity of the surface wind and the inland movement of the sand. Sand deposited in the vegetation forms a continuous sand ridge parallel to the shoreline. Directly behind the foredune, the wind currents scour the area down to the water table and form a low wetland called a deflation plain. The sand laden wind continues to move inland depositing the sand which creates sand area landforms.

Oregon has approximately 314 miles of ocean shoreline which includes 255 miles of beaches and 195 miles associated with the dune building process. In total the dune areas include approximately 164,380 acres of the coastal zone with 19,085 acres of active sand areas, 23,325 acres which are conditionally or semi-permanently stable, 38,980 acres of interdune areas, and 81,800 acres which are stabilized sand areas (Table 2, Beaches and Dunes Inventory). The degree of stabilization[25] of the landform is generally the primary factor in determining the level of suitability or tolerance of a sand area for a particular use. Most sand areas are stable or conditionally stable. However, this stability can be damaged and the area can be returned to an active condition if the natural limitations of the landform are exceeded. Therefore, uses allowed in sand areas should be based upon the requirements of the use and its compatibility with the effected landform type.

Recreational opportunities in sand areas are diverse and essential to the experience of being on the coast. The dynamic interface between land and sea has always held a fascination for man. Oregon's beaches are being managed as a public recreational resource. The majority of the parks and many of the recreational developments on the coast occur in or adjacent to sand areas. Although beaches are probably the area that most recreationists associate with the coast, the dunes, particularly the open sand areas, are also highly popular. Off-the-road-vehicle (ORV) use, hiking, horseback riding, hang gliding, hunting, wildlife observation and innumerable other recreational activities occur in these areas. Beaches and open sand areas are well suited for undeveloped recreational uses because these landforms will tolerate high levels of human impact. However, in some areas conflicts arise between the activities themselves (Table 4, Beaches and Dune Inventory). Public safety hazards and annoyance factors indicate that ORV's are often incompatible with pedestrian and equestrian use. With increasing numbers of people participating in these activities it will be necessary in some areas to separate these uses and designate specific

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[24] Littoral drift is the material such as gravel or sand which is moved by waves and currents (long shore transport) through the littoral (close-in water) zone. The material comes from the watersheds of coastal rivers and streams and erosion of the ocean shoreline.

[25] Stabilization is determined in part by the lack of active sand movement or dune migration because of vegetative cover as well as soil development, soil moisture, and the degree of stabilization in adjacent areas.

areas for off-the-road vehicles.[26] Other sand area landforms have less capacity to tolerate human impact. For example, conditionally stable open sand and hummocky areas are particularly fragile[27] and foredunes can be damaged by the breaching and trampling of recreationists. Therefore, recreational access and the types and levels of use should be based upon the capacity of the landform type.

Sand areas also possess outstanding natural beauty and evidence of the dynamic forces of nature. The diversity in their character ranges from the openness and broad vistas of active open sand areas to the dense forest cover of an older stabilized dune. This variety allows an extraordinary richness of experience within a small area. Changes in season, tides, weather and time of day add another dimension to the dynamic character of sand areas. In the OCC&DC Visual Inventory, 10 of the 26 representative landscapes of the coastal zone were related to sand areas and received high ratings in the visual evaluation.[28]

Many of the areas identified as suitable for urbanization are associated with sand areas (OCC&DC Inventory of Areas Suitable for Urban Development). Because most sand areas are in a stable condition, this does not represent a significant problem for urban development except where water and sewer services are not available. Use of septic tanks will create pollution problems due to the high vertical and horizontal (iron banding) permeability of older dunes. The vital role of the vegetation in retaining the stability of these landforms must also be recognized. If the vegetation is removed or sufficiently disturbed (root damage and moisture loss) and no preventive measures are taken to re-establish cover, then an older stabilized dune can be reactivated.

There are several types of sand area landforms which are unstable and generally unsuited for development. Active or conditionally stable foredunes, which are subject to ocean undercutting, are highly unstable due to wind erosion and blowing sand and wave action. Open sand areas and dry and wet hummocks are also unstable due to active dune migration. Open sand conditionally stable areas represent a fire hazard as well as being highly susceptible to renewed instability, but can be developed under careful management. Deflation plains and wet interdune areas are not well suited for development because they are highly significant wildlife habitat areas and present problems from flooding and ponding, compressible soils and surface and sub-surface pollution. The suitability of some of these unstable areas for various uses can be improved by careful management. However, individual site evaluations would be necessary.

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[26] One of the OCC&DC General Recreation Policies states the ORV use should occur in designated areas and that these areas should be selected according to their physical suitability for that use.

[27] Fragile in terms of stability and also significant wildlife values in the case of hummocky areas. Disturbance of the vegetation areas can return them to an active, blowing sand condition.

[28] Eight of the ten representative landscapes in sand areas were placed in the highest classification because of their obvious and strong association with the ocean and the "coastal experience". The Clatsop Plains, much of the Coos Bay dune sheet, Sand Lake and the sandspits on the Nehalem, Tillamook, Netarts, Salmon River, Alsea Bay, Sixes, Elk and Euchre Creek were identified as being of exceptional visual (experimental) importance.

Erosion of the ocean shoreline contributes to littoral drift. Rates of ocean undercutting are influenced by: resistance of the material to erosion; slope and vegetative cover. Hence shoreline erosion of coastal terraces and the unconsolidated sediments of sand area landforms is more rapid than a basaltic headland. Ocean undercutting becomes a hazard to development and other uses when the rebuilding action of summer waves fail to replace the sand lost by the erosion of winter storms. Ocean undercutting is a serious problem, especially on parts of the central coast. Bulkheading of the shoreline reduces the available sand supply to sand areas. In some areas, natural and artificial barriers to littoral drift, such as headlands, rivers and jetties, create a critical relationship between local sand sources and the continuance of sand areas in their vicinity. Some beaches on the central coast seem to be deficient in sand, therefore studies are needed to determine the impact of bulkheading, the relative importance of other local sand sources and project future shoreline erosion and accretion trends (Beaches and Dune Inventory, page 80).

Active dune migration or dune advancement sometimes threatens public works such as roads, navigation channels and public and private property. However, these active dune processes also are valuable recreational and aesthetic resources. Therefore, conflicts arise over whether or not artificial dune stabilization should occur. In Honeyman State Park, for example, the expanse of open sand area and the lake are the primary recreational features, but the active dune movement is closing the outlet of the lake and will cause the water to become stagnant unless part of the open sand area is artificially stabilized. The decision to stabilize an active dune should be done in conformance with comprehensive plans to make sure public benefits and costs are adequately considered.

There are many areas of significant wildlife habitat in sand areas. The stabilized dune forests contain the greatest species diversity, but the deflation plains, wet interdunes and hummocky areas provide more significant habitat values. Waterfowl and special interest species such as Whistling Swan depend on the deflation plain as a feeding, and resting habitat. Snowy Plover require the driftwood area adjacent to foredunes.

Recommended Actions

1. State and local governments should approve proposed recreational uses of those sand landforms identified as having high value for recreation use (as identified in the OCC&DC Beaches and Dunes Inventory) unless it is demonstrated that the net social benefits of approving an alternative proposed use exceed the net social benefits of disapproving it.[29]

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[29]Three OCC&DC inventories: Beaches and Dunes of the Oregon Coast, Visual Resource Assessment of the Oregon Coast, and the recreation section of Resource Analysis of Oregon's Coastal Uplands discuss the outstanding recreational values of sand areas, particularly active open sand areas and beaches. This statement is also reinforced by OCC&DC General Recreation Policies which recognize the need for preservation of areas having outstanding potential for recreation (ID-1) and the need for use limitations based on the capability of the resource to support that use (ID-2).

2. State and local government should designate certain sand areas for preservation in their natural state in order to allow for continuance of natural dune processes for the purposes of scientific study and protection of scenic, recreation and wildlife habitat values. (B&D 9, 8RA, 2)

3. Local government should require that dune stabilization be conducted in conformance with use designations included in comprehensive plans. (Inventory)

4. The State, in cooperation with the Soil Conservation Service, should encourage and support additional studies of sand area carrying capacity, including the impact of motor vehicles, pedestrians and livestock. (B&D 12RA)

5. The State should develop and implement, with the cooperation of concerned agencies, an education program to explain beaches and dune processes to the general public and to schools. (B&D 4RA)

(NOTE: The following additional recommended action will be considered further by the OCC&DC once the wording is improved:

> "State and local government should designate only the sand landforms older stabilized dunes and older foredunes (as identified in the OCC&DC inventory) as suitable for development or intensive use without need of further evaluation through a site investigation. (Inventory)")

Implementation

The State is charged with the management responsibility for beaches by existing statute. No additional measures are considered to be necessary for protection of their recreational values. Cities and counties in the coastal zone will have the primary responsibility in planning for the appropriate uses of privately owned sand areas other than beaches.

The appropriate state agency will have responsibility for the development of criteria for the sand area element of local comprehensive plans and state agency plans and review of local and state agency plans for compliance with the State criteria. This agency may delegate its review responsibilities to the appropriate regional or functional agencies such as the Department of Geology and Mineral Industries and should coordinate its efforts with the U.S. Soil Conservation Service. State and federal agencies have the primary planning responsibility for sand areas within the lands they administer.

Projected Impacts

The social, economic and environmental impacts generated by this policy can be separated into: (1) those impacts associated with the comprehensive planning process and (2) those impacts resulting from comprehensive planning.

Some of the measures required to maintain the values and uses of sand areas are already covered in part by existing water quality controls, the Oregon Beach Law, fish and wildlife statutes, and regulations of local soil and water conservation districts.

The inclusion of a sand area element in local comprehensive plans and state agency plans would require some increased time, labor and material costs in jurisdictions which contain sand areas. These increased costs to local and state agencies may be offset by the additional employment and income generated by the process and the receipt of federal coastal zone management funding.

Understanding of the physical and biological limitations in sand areas for various uses provides a better basis for comparison of sand areas with other resource and social and economic considerations and will generate more appropriate land use decisions. Some uses will be encouraged to seek alternative locations, but adverse economic impacts can be reduced by providing incentives for development in areas which are most suitable. Positive social, economic, and environmental impacts will result from the reduction and avoidance of adverse effects upon the values of sand areas.

2. Regulation of Uses in Sand Areas

Policy Statement

a. *In sand areas other than older stabilized dunes and older foredunes (as identified in the OCC&DC inventory), state and local government shall base approval or disapproval of uses, in part,[30] on a site investigation report which has been prepared by a qualified sand specialist[31] and provided to the applicable unit of government by the developer. The report shall evaluate the capability of the site to support the proposed development without endangering life, property or environment and shall describe:*

   (1) the type of development (use) proposed;

   (2) the temporary and permanent stabilization programs and the planned maintenance of this vegetation once it is established; and

   (3) the methods for protecting the surrounding area from adverse effects of the development and stabilization. (B&D 4,5,7,10)

b. *State and local government shall not approve any proposed use of a sand area that is likely to cause any of the following conditions unless it is demonstrated that the net social benefits of approving the use in the sand area exceed the net social benefits of disapproving the use:*

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[30] Other factors that should be considered in evaluating developments in the coastal zone are included in the General Policies, Phase II, #IA6.

[31] A sand specialist could be a soil scientist, geologist or another individual qualified to conduct site evaluations based on overall education, experience and knowledge of the type of area being evaluated.

[32] A policy addressing retention and restoration of vegetative cover for all areas in the coastal zone is included in General Policies, Phase II, #IA8.

(1) excessive damage to existing vegetation including moisture loss and plant root damage;[32]

(2) exposure of stable and conditionally stable areas to erosion;

(3) slope instability;

(4) pollution or excessive drawdown of groundwater;[33] *and*

(5) interference with significant wildlife habitats.[34] *(B&D 5RA; Inventory)*

Background

Policy #1 provides the general framework for management of the sand area resource. The planning that is guided by this policy will provide general use designations for the various types of sand landforms based on inventory information and state developed criteria. Certain sand landforms such as older stabilized dunes and older foredunes may be designated for development or other intensive uses. However, due to the physical and biological limitations of other sand landforms, additional site-specific information is needed prior to approving or disapproving proposed uses of them. Therefore, to complete the recommended management approach for sand areas, it is necessary to establish a regulatory procedure which requires site investigations in applicable sand areas.

Many uses may be possible on a particular sand site depending on the landform type, the potential impact of the proposed use and the ability to alter the natural limitations encountered. A site investigation in providing site-specific information will allow for a needed flexibility in making the complex decisions related to use of these sand areas.

The physical and biological capabilities of most types of sand areas vary in relation to the existence and interaction of sand supply, wind and wave forces, water and vegetation. The existing vegetation or potential for establishing vegetation is critical to the use suitability and capability of the site. The stability of a site, its resistance to wind, erosion, ocean undercutting and mass wasting, most often depends on how well the vegetative cover is established and protected. Therefore, sand area stabilization and protection and maintenance of existing vegetation are important elements of resource management.[35] The inventory emphasizes this point and the proposed policies include it as a major evaluative criteria.

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[33]General Water Policies, # IB1 and 6 also address this issue.

[34]The most significant habitats in sand areas as described by the OCC&DC Beaches and Dunes Inventory are in the deflation plains. Up to 92 wildlife species use these areas. Of special note is the Whistling Swan which is dependent on this habitat.

[35]The absence of vegetation (i.e., unstabilized sand areas) is important to many of the recreational uses and scenic values of sand areas and, therefore, proper management would not always require stabilization programs.

The presence of water is essential to the existence of healthy vegetation. Accordingly, uses which would threaten moisture loss need to be regulated so that enough water is available to sustain the vegetation and maintain stabilized conditions. Cutting and removal of vegetation as well as excessive drawdown of groundwater could affect the available moisture in the soil.

The groundwater supplies in sand areas also are important as a source of domestic water for both communities and individual users. However, care must be taken to not exceed yield limitations of these supplies. Over withdrawal of freshwater could lead to intrusion of salt water into the wells.[36] In addition, groundwater in sand areas is highly susceptible to pollution from surface or subsurface waste discharges due to the vertical and horizontal permeability (high infiltration rates) of sand landforms.[37]

A continuing sand supply is important in the dune building process, particularly that of foredunes which protect property and environment from sand damage (see background for Policy #3). The recreational values of open sand areas (oblique and transverse dunes and beaches) are also dependent on a continuing supply of sand. Therefore, removal of sand and interference with the natural sand supply process should be controlled so that protective and recreational values are retained. The longshore transport of sand (littoral drift) is a major part of this natural process and one that is affected by developments such as jetties.[38]

The criteria recommended for evaluating proposed uses of sand areas and several of the recommended actions pertaining to specific uses are directed toward maintaining the appropriate (depending on management objective) interaction of sand supply, water and vegetation.

Recommended Actions

1. The state, after consultation with local governments and the Soil Conservation Service, should specify those data that must be included in the site investigation reports used in evaluating development proposals in sand areas.

2. The state, in cooperation with local governments and the Soil Conservation Service, should develop a statement of qualifications for sand specialists to assist local government and the public in selecting individuals to conduct evaluations of projects in sand areas.

3. State and local government should control or design access into or through sand dunes areas, particularly conditionally stable dunes and dune complexes, so that the stability of the area is maintained, scenic values are protected and fire hazards avoided.[39] (B&D 13, 9RA)

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[36]Geologic Hazards Inventory of the Coastal Zone, (p. 28).

[37]Beaches and Dunes of the Oregon Coast, (p. 56, 59, 65).

[38]Beaches and Dunes of the Oregon Coast, (p. 23).

[39]General Transportation and Access Policy #IC3 addresses the issue of access for many areas in the coastal zone.

4. Local government should allow cutting and removal of timber and understory vegetation or ground cover in sand areas only if the planned method for removal will not threaten the survival of the adjacent plant communities due to subsequent moisture loss, or root damage.

5. State and local government should permit removal of sand from sand areas only when it is necessary to protect private or public property from sand damage or when such removal will not adversely affect the environment or the stability of adjacent areas as determined by a site investigation. (B&D 11)

6. State and local government should regulate driftwood removal from sand areas and beaches for both individual and commercial purposes so that scenic values and the dune building process are not adversley affected.[40] (B&D 8)

7. Local government should regulate grazing of domestic animals on stabilized dune areas on an assigned density basis as determined by site investigations. (Clatsop S&WCD; B&D Conflict #17, Inventory)

8. In developing structures that might cause excessive diminishment of sand supply or interruption of the longshore transport of littoral drift, the developer should investigate possible methods of sand by-pass.

<u>Implementation</u>

Local governments would require and review site investigation reports as a condition of whatever evaluative procedure (special permit, zone change, subdivision ordinance, building permit) is used in considering proposed uses of sand areas. Assistance in evaluating site investigation reports should be provided to local units of government by the state.

In areas of public ownership, the applicable public body should be required to conduct a site investigation prior to changing the use of or developing the property.

When the proposed uses of sand areas include "activities of statewide significance,"[42] the state (the appropriate state agency in consultation with the Department of Geology and Mineral Industries and the U.S. Soil Conservation Service) should participate in the evaluation process. Also, if the site is within an "area of critical state concern", the state should have review authority.

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[40] In the beaches and dunes inventory log debris is credited with playing a part in the formation of foredunes (p. 38).

Footnote 41 has been deleted.

[42] As defined in SB100 - The planning and siting of public transportation facilities; public sewage systems; water supply systems; solid waste disposal sites and facilities and public schools. Others may be recommended by LCDC and approved by the Legislature.

Projected Impacts

Implementation of these policies would have a positive impact in that the potential for damage to life, property or environment would be reduced. The specific increase in social benefits and decrease in social costs that would result is not known. Of less significant impact is the increase in wages or employment or both of sand specialists.

Negative impacts include the likely increase in the time it takes to receive approval or disapproval of uses in sand areas and the increased resources that will be needed in the regulatory process. Without state assistance or cooperative arrangements among governments, individual local governments would incur increased costs in obtaining staff expertise to evaluate use proposals. Private and public development costs (construction, maintenance, repair) would probably increase.

3. Maintenance of Foredunes

Policy Statements

a. *State and local government shall permit development on active foredunes and on conditionally stable foredunes which are subject to serious ocean undercutting only when it is demonstrated that the social benefits of development on these sand areas exceed the social costs. (B&D Conflict and Inventory)*

b. *State and local government shall allow breaching of foredunes only on a temporary basis for emergency purposes (e.g., fire control, cleaning up oil spills) and shall require that these foredunes be restored once the emergency passes,*[43] *unless it is demonstrated that the social benefits of permanent breaching of the foredune exceed the social costs.*

Necessary Actions

The state in cooperation with local governments and state and federal agencies shall establish criteria and procedures for breaching of foredunes and restoration of breached foredunes.

Background

Both policy #1 and #2 apply to foredunes as one of the landforms within sand areas. However, separate policies directed specifically at active and certain conditionally stable foredunes are considered necessary because:

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[43] In the Dunes National Recreation Area, managed by the U.S. Forest Service, variance from this policy is necessary in order to maintain a continuing supply of sand to inland recreational areas.

(1) these foredunes have very little, if any, tolerance for most activities that might occur in sand areas with the exception of undeveloped pedestrian access and wildlife habitat.[44]

(2) the potential for a rapid change in the foredune landform due to wind and wave erosion is ever present.

(3) foredunes provide a valuable protective function keeping sand-laden wind from penetrating further inland and damaging property, facilities and wildlife habitat.

(4) the foredunes are an area of geological hazard due to wind erosion, ocean undercutting and tsunamis.[45]

There are some 1,400 acres of active foredunes and 1,950 acres of conditionally stable foredunes stretching 138 miles along the Oregon coast. Many of these dunes are a direct result of some of man's first efforts in sand stabilization during which European beachgrass was introduced.[46] Other foredunes are the outcome of the naturalization of European beachgrass and its growth along the sand areas of the coast. This vegetation provides one of the key elements of a dynamic dune building process. The ocean deposits sand on the beaches and the wind carries it inland until its velocity is reduced by the vegetation at which point the sand is deposited. The vegetation then grows up through the sand and the process repeats itself until a sand ridge (the foredune) is established.

Interference with this process will directly affect the characteristics of the foredune. If the vegetation is removed or not allowed to continue its growth and the sand is exposed, a blowout or rapid wind erosion may occur causing encroachment of sand on previsouly protected property and wildlife habitat.

Although few species of wildlife use the beachgrass on foredunes as habitat, modification of the foredunes may have adverse effects on the adjacent habitats of the Snowy Plover[47] as well as some 54 species of wildlife found on the landward side of the dune and 98 species of wildlife inhabiting the deflation plain.

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[44]Table 3 of the OCC&DC inventory Beaches and Dunes of the Oregon Coast describes tolerance levels of active foredunes and recently stabilized foredunes (conditionally stable).

[45]The Geologic Hazards Inventory of the Oregon Coastal Zone describes these hazards and their relationship to dune lands.

[46]Between 1910 and 1935 sand stabilization projects were initiated in the Coos Bay dune sheet using European beachgrass and in 1935 the U.S. Soil Conservation Service and the Civilian Conservation Corps began sand stabilization projects on the Clatsop Plains.

[47]The Snowy Plover is dependent on the beach-driftwood habitat which lies adjacent or parallel to foredunes.

Developments such as housing on active foredunes may result in wind erosion of the dune, damage to the development or adjacent property, and hazards to human life. The damages of housing construction on active foredunes in Clatsop, Tillamook and Lincoln Counties are illustrated in the inventory (p. 39-48). Rapid movement of sand by the wind not only damages the development itself but causes damage and maintenance costs to be increased for adjacent property owners. On conditionally stable foredunes where wind erosion may not be a major problem there is still the threat of ocean undercutting and seismic sea waves (tsunamis). The undercutting of wind stable foredunes and active foredunes in Salishan Spit, Lincoln County during the winter of 1972-73 and on Bay Ocean Spit, Tillamook County during 1930-52 are prime examples of ocean undercutting.[48] The past and potential effects of tsunamis are described within the beaches and dunes inventory (p. 49-50) and within the Geologic Hazards Inventory of the Oregon Coastal Zone (p. 39-41).

As indicated, the growth and stability of active foredunes or of conditionally stable foredunes is dependent on sand supply, water, vegetation cover, and wind velocity. The uses that affect or modify these controlling elements need to be managed if the protective function of this resource is to be preserved.

In some special cases the protection of the foredune may not be desirable. For example, where inland sand areas are considered best used for recreational purposes that require large expanses of open sand, removal of the foredune to allow replenishment from the beach sand supply may be necessary. However, such a situation is not likely to occur except within the Dunes National Recreation Area.

In most cases, removal or serious alteration to the protective foredunes will mean that: "substantial sand deposition damage will result to man's existing developments and public works, lakes, wildlife areas, agricultural land and forests. In other words, the active foredunes or those foredunes conditionally stable provide a protective wind barrier to what exists landward of them and the removal of the barrier will increase wind erosion and sand deposition in the landward area."[49]

Recommended Actions

1. State and local government should investigate all known methods of inducing foredunes artificially on the continental shelf, for federal implementation, wherever pre-existing developments are threatened by undercutting erosion of present foredunes.

2. State and local governments in cooperation with federal agencies should develop criteria for construction of beach front protective structures, and one of the criteria should be an evaluation of the net social benefits and costs.

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[48]Figures and references to these occurrences are on p. 46-47 of the Beaches and Dunes Inventory.

[49]Beaches and Dunes of the Oregon Coast, USDA Soil Conservation Service and OCC&DC, Review Draft, November 1974, p. 50.

Implementation

Cities and counties should have the primary responsibility for development and enforcement of specific regulations for active and conditionally stable foredunes.[50] State and federal agencies should have responsibility for regulating use of sand landforms within their ownership. Regulations developed should be complementary to and based on the applicable local and state comprehensive plans mentioned in Policy #1.

The appropriate state agency should assist in the development of regulations and should review local and state regulations pertaining to foredunes. The U.S. Soil Conservation Service and its local conservation districts as well as the State Department of Geology and Mineral Industries should be used by the appropriate state agency in program review and assistance. These same agencies should be asked to provide local governments with technical assistance and information through this agency's governmental coordination process.

Projected Impacts

The positive impact of these two policies on foredunes would be as described in the background. That is, the potential for damage to property and environment as well as for loss of human life would be reduced. This in turn would have a beneficial economic impact in that replacement and repair costs to facilities and property damaged also would be reduced.

The negative impacts of the policies would include the costs incurred from increased regulation and restoration of the sand areas. Also, there would be some decrease in per capita income and employment due to prohibition of development on foredunes and possible denial of ocean view for property located behind the dunes.

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[50] Several local governments have identified the need for additional regulations in sand areas. Coos County is considering an Interim Natural Resource Zone which would help protect "dune lands" from uses which would significantly damage or destroy the resource values. Lincoln County has a natural resource zone (A-1) which restricts the type of uses on "dune lands". Tillamook County's comprehensive plan calls for engineering reports which evaluate the capacity of fragile sand areas to support development prior to consideration of such development. This plan also recommends establishment of standards for development and use of sand spit and dune areas. Sand areas of the Clatsop Plains are regulated under the guidance of the Clatsop Soil and Water Conservation District. These regulations include requirements for stabilization and prohibition or restriction of access and other uses. A recent hazardous area plan for the Clatsop Plains, developed by soil scientists from Oregon State University, supports these regulations for the Clatsop Plains and further recommends that "disturbance of the fore-dune by construction or excavation be prohibited". Finally, the City of Cannon Beach has an ordinance requiring a setback of developments from areas of erosion potential on the beach front.

SUPPORTING INFORMATION

Consideration of the National Interest

The Federal Government has declared an interest in sand areas for their recreation value by establishing the Dunes National Recreation Area (NRA) under the management of the U.S. Forest Service. Because of this national interest in sand areas these policies will be referred, after preliminary review by the OCC&DC, for review and comment to the Federal Highway Administration, the U.S. Corps of Engineers, the Soil Conservation Service, the U.S. Forest Service, the National Park Service and the Bureau of Land Management in accord with Section 923:15 of the Coastal Zone Management Act of 1972.

State Review

Policies included in this document have included recommendations and concerns of the Department of Geology and Mineral Industries, Division of State Lands and Wildlife Commission. Representatives of these agencies as well as the Department of Geology at the University of Oregon have provided considerable assistance in the early development of sand area related policies. After preliminary review by the OCC&DC, these Phase II policies will be forwarded to these and other state agencies for review and comment.

Implementation Process and Preference of Uses

Primary implementation of sand area policies will be through the local (city and county) planning and regulatory process, with state review of "Activities of Statewide Significance" or for "Areas of Critical State Concern" coordinated by the Land Conservation and Development Commission (LCDC). Additional ordinances or special controls which may be adopted by local jurisdictions should be reviewed by the Department of Geology and Mineral Industries. Additional assistance should be obtained from the U.S. Soil Conservation Service and local soil and water conservation districts.

Inventories indicate that the capability and suitability of sand areas for various uses will vary according to the type of sand landform, the particular site characteristics (in terms of sand supply, water availability and vegetation) and the potential impacts of the proposed use. Therefore, site evaluation is more desirable than determination of uses on a broad, regional basis. However, the policies and recommended actions do identify management concerns which should be integrated into the planning process.

The OCC&DC Geological Hazards Inventory of the Oregon Coastal Zone contains a preference of uses for the geological hazards perspective of active dunes, beaches, stable and conditionally stable dunes, and interdune areas. However, establishing specific preferences among the diverse values of recreation, aesthetics, wildlife habitat and development for sand areas is a local option (with exception of state and federal land). The policies provide some management guidelines

for these decisions.

Areas of Critical State Concern

The State of Oregon through its Beach Law (Act 601 - 1967) has identified a statewide interest in the use of its beaches. The extent of this law and its administration by the State Parks and Recreation Office of the Highway Division results in more extensive state management than would occur in designated areas of critical state concern.

Only one sand area, that which borders the Dunes National Recreation Area (primarily between the NRA boundary and the Coast Highway), is recommended for consideration as an area of critical state concern. The strong competition for use of this area; the multi-jurisdictional (local, state, federal) responsibility for planning and regulation and the differing opinion as to proper management of the area have created a need for coordination. The fact that the Federal Government has established the adjacent NRA as a scenic and recreational resource of national significance adds to the importance of this area. This expression of national interest in turn calls for special consideration by the state in fulfilling its Coastal Zone Management responsibilities.

Research and Information Needs

To assure effective management of Oregon's sand areas and resolve conflicting demands upon these resources, continuing and more detailed investigation is necessary to provide an objective basis for decision making. The following studies are considered necessary and beneficial:

(1) A comprehensive analysis of the carrying capacity of each of the sand area landforms for recreational use (including ORV's and pedestrian access), livestock and development;

(2) Project demands for various uses of sand areas and identify criteria for selecting areas suitable for these uses;

(3) Evaluation of the extent to which littoral drift and longshore transport of sediment contribute to the sand supply of beaches, dunes and sand spits in comparison to more local sources (i.e., nearby headlands and shoreline erosion and coastal streams); projection of future trends in replenishment and identification of the drift sectors;[51]

(4) A detailed assessment of the importance of driftwood in the dune building process and the feasibility and likely impact of commercial removal of driftwood; and

(5) Measurement of rates of dune migration and the natural dune building process.

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[51] Drift sectors are the interactive areas in which these local erosion and accretion processes are confined.

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MAP APPENDIX

LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredunes
H	Active dune hummacks
IFD	Inland foredune
M	Mountain scarp
ODS	Older stabilized dunes
OFD	Older foredunes
OS	Open dune sand
(OS)	Designates items of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

DS	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP

CLATSOP COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

1 0 1 2 MILES
SCALE 1:63,360

USDA-SCS-PORTLAND, OREG. 1974

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Sheet 1 of 2

LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
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WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

(OS)	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP
CLATSOP COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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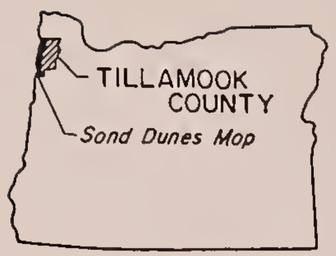
SCALE 1:63,360

USDA-SCS-PORTLAND, OREG. 1974



LOCATION MAP

DUNE LEGEND

AID	Active inland dune
B	Beoch
CT	Coostol terroce
DC	Dune complex of OS, OSC, DS, ond W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredune
H	Active dune hummocks
M	Mountain scorp
ODS	Older stabilized dunes
OS	Open dune sond
(OS)	Designates items of secondary importonce
OSC	Open dune sand conditionolly stoble
W	Wet interdune
WDP	Wet deflotion plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

(OS)	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP

TILLAMOOK COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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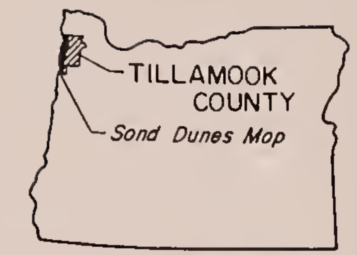

LOCATION MAP

DUNE LEGEND

AID	Active inland dune
B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
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(OS)	Designates items of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMP	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

OS	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP

TILLAMOOK COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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Sheet 2 of 3

DUNE LEGEND

AID	Active inland dune
B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredune
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WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

- Dune or interdune boundary
- Dune movement threatening or stable dune being wind eroded
- Ocean or river undercutting
- Lakes or ponds

SAND DUNES MAP

TILLAMOOK COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

JUNE 1974

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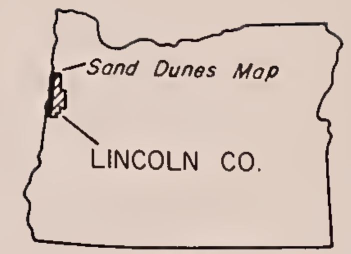

LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
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OFD	Older foredunes
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(OS)	Designates items of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

(OS) Dune or interdune boundary

Dune movement threatening or stable dune being wind eroded

Ocean or river undercutting

Lakes or ponds

SAND DUNES MAP
LINCOLN COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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Sheet 1 of 2

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SAND DUNES MAP
LINCOLN COUNTY, OREGON
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974
LOCATION MAP
Sand Dunes Map
LINCOLN CO.
DUNE LEGEND
B Beoch
CT Coostol terroce
DC Dune complex of OS, OSC, DS, ond W
DS Younger stabilized dunes
FD Recently stabilized foredunes A
FDA Active foredunes
H Active dune hummocks
M Mountoin scorp
ODS Older stobilized dunes
OFD Older foredunes
OS Open dune sond
(OS) Designotes items of secondory importonce
OSC Open dune sond conditionolly stoble
W Wet interdune
WDP Wet deflotion plain
WFP Wet flood ploin
WMF Wet mountoin front
WSP Wet surge ploin
GENERAL LEGEND
Dune or interdune boundary
Dune movement threotening or stoble dune being wind eroded
Oceon or river undercutting
Lakes or ponds
SCALE 1:63,360
2 MILES
Joins To Sheet I
Joins Center Portion
Joins North Portion
Joins South Portion
Yaquina River
Beaver Cr.
Alsea River
Waldport
Lint Slough
Eckman L.
Big Cr.
South Fork
Virgie Cr.
Starr Cr.
Yachats
Yachats River
LINCOLN CO.
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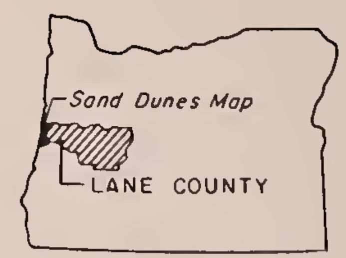

LOCATION MAP

DUNE LEGEND

B	Beach
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredunes
H	Active dune hummocks
M	Mountain scarp
ODS	Older stabilized dunes
OS	Open dune sond
(OS)	Designates items of secondory importonce
OSC	Open dune sand conditionolly stable
W	Wet interdune
WDP	Wet deflotion ploin
WFP	Wet flaad ploin
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

- (OS) Dune or interdune boundary
- Dune movement threotening or stable dune being wind eroded
- Oceon or river undercutting
- Lokes or ponds

SAND DUNES MAP

LANE COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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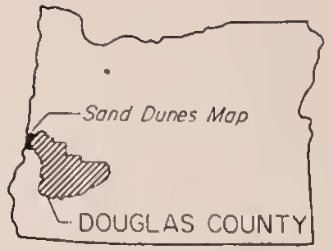

LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS, and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
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M	Mountain scarp
ODS	Older stabilized dunes
OS	Open dune sand
(OS)	Designates items of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

(OS)	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP

DOUGLAS COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

JUNE 1974

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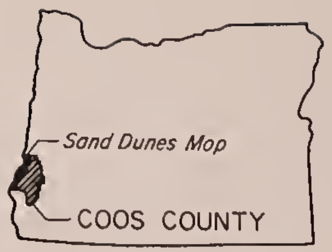

LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredune
FL	Fill land
H	Active dune hummocks
M	Mountain scarp
ODS	Older stabilized dunes
OS	Open dune sand
(OS)	Designates item of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

- OS — Dune or interdune boundary
- Dune movement threatening or stable dune being wind eroded
- Ocean or river undercutting
- Lakes or ponds

SAND DUNES MAP
COOS COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

1 0 1 2 MILES
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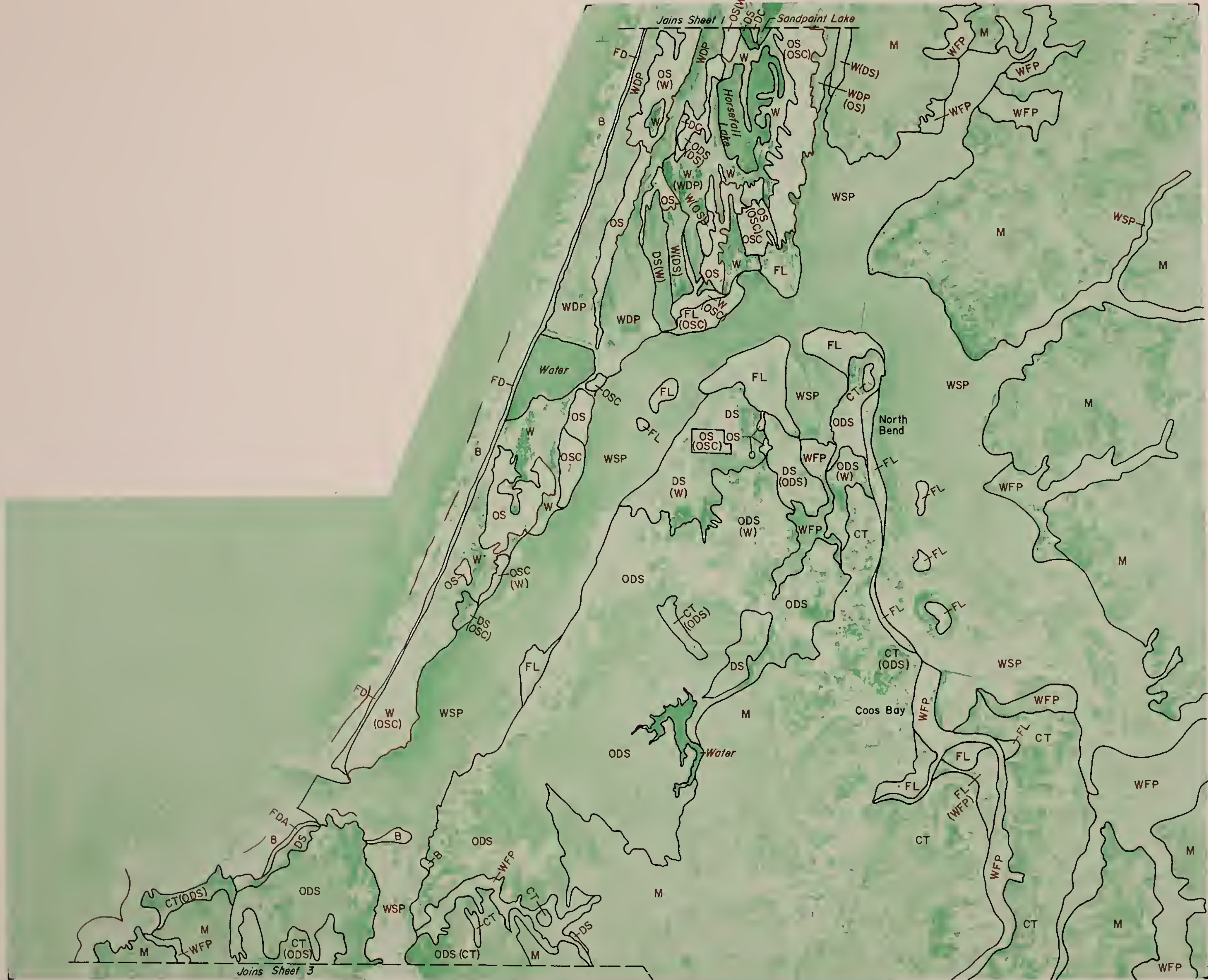
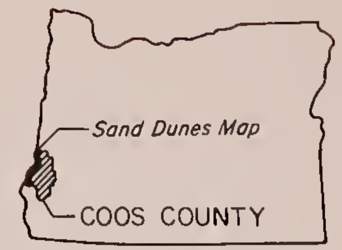
Sheet 1 of 3

USDA-SCS-PORTLAND, OREG. 1974





LOCATION MAP

DUNE LEGEND

B	Beach
CT	Coastal terrace
DC	Dune complex of OS, OSC, DS and W
DS	Younger stabilized dunes
FD	Recently stabilized foredunes
FDA	Active foredune
FL	Fill land
H	Active dune hummocks
M	Mountain scarp
ODS	Older stabilized dunes
OS	Open dune sand
(OS)	Designates item of secondary importance
OSC	Open dune sand conditionally stable
W	Wet interdune
WDP	Wet deflation plain
WFP	Wet flood plain
WMF	Wet mountain front
WSP	Wet surge plain

GENERAL LEGEND

OS	Dune or interdune boundary
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SAND DUNES MAP

COOS COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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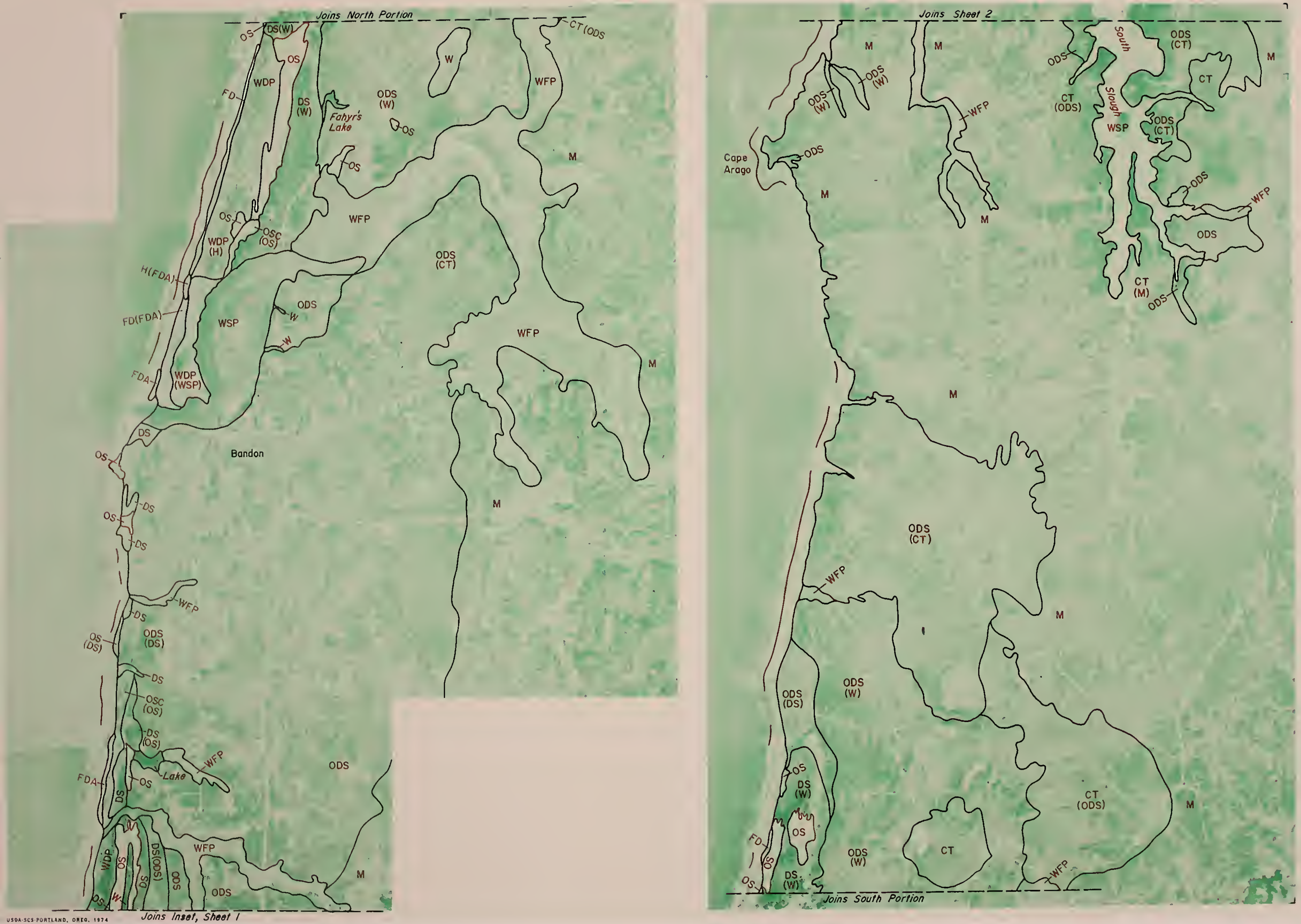

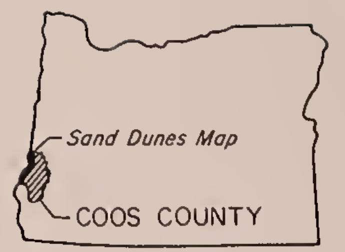

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SAND DUNES MAP
COOS COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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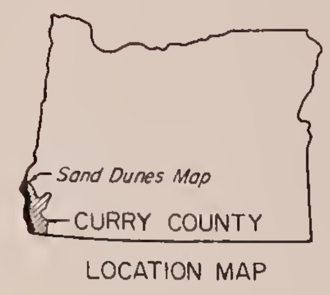
Sheet 3 of 3

USDA-SCS-PORTLAND, OREG. 1974



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GENERAL LEGEND

(OS)	Dune or interdune boundary
	Dune movement threatening or stable dune being wind eroded
	Ocean or river undercutting
	Lakes or ponds

SAND DUNES MAP

CURRY COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JUNE 1974

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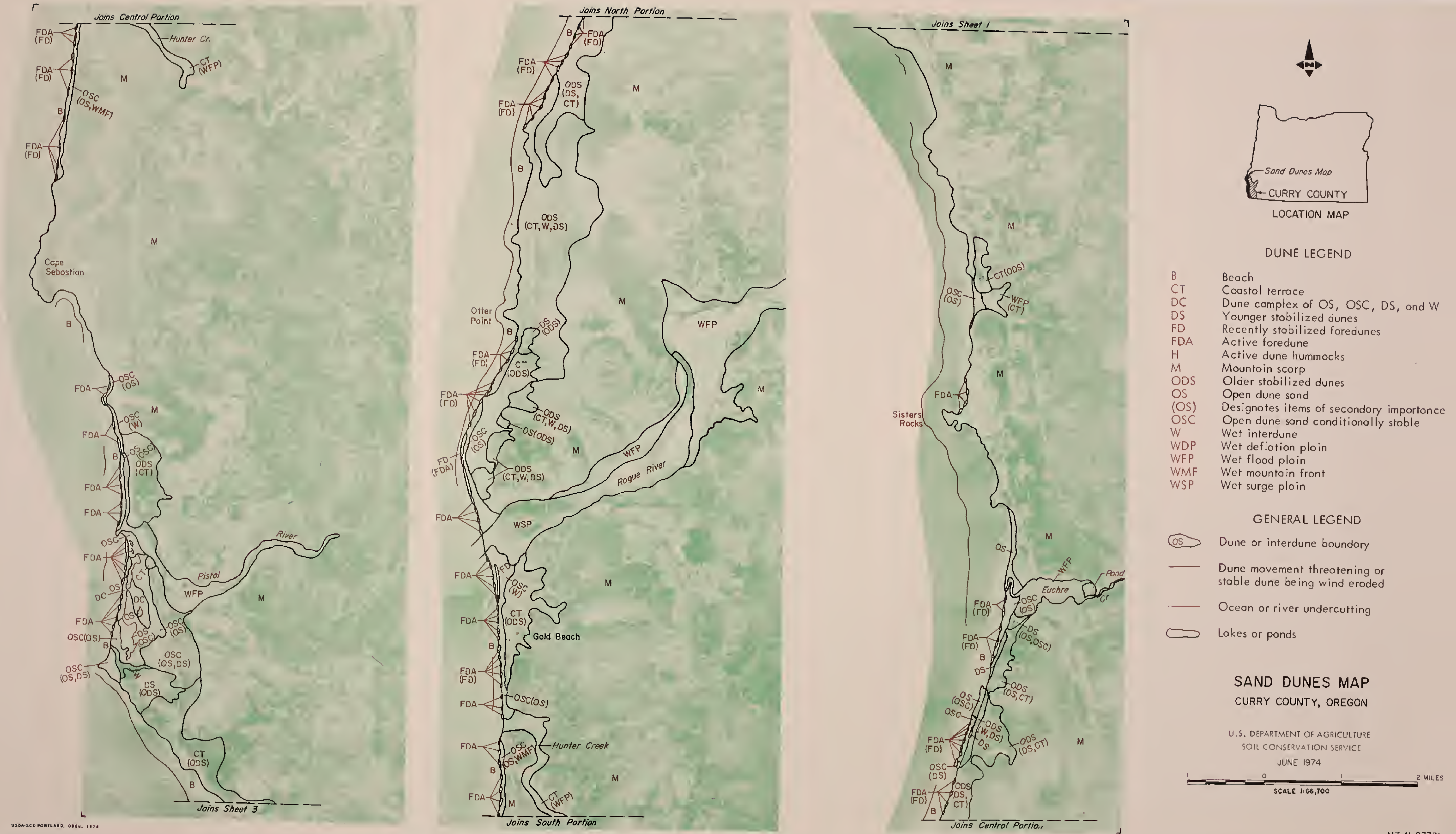

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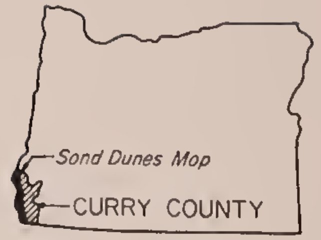

LOCATION MAP

DUNE LEGEND

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SAND DUNES MAP

CURRY COUNTY, OREGON

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

JUNE 1974

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USDA-SCS-PORTLAND, OREG. 1974

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